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ADVANCED REVIEW

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Changing behavioral responses to heat risk in a warming world: How can communication approaches be improved?

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Abstract

Heat risks, such as those associated with heatwaves, are increasing in frequency, severity, and duration due to climate change. The ways in which people around the globe perceive and respond to heat risks are now of great importance to reduce a range of negative health outcomes. A growing body of literature aims to assess the factors that influence people's behaviors in relation to heat risks. This research can inform better interventions, such as improved communications approaches, that attempt to facilitate adaptive behavioral responses to such risks. This review focuses on how insights from behavioral and attitudinal studies about heat risk responses can inform communication approaches. These insights are organized into three key themes: (1) *Behaviors*—What types of actions can be taken by people, and what evidence is there for adaptive behavior? (2) *Antecedents*—Which individual and contextual factors can influence people's behaviors? (3) *Communications*—How can existing insights be better integrated into interventions? Aspects of communication, including the role of message characteristics, messenger, and imagery, are discussed, with examples of messages and narratives that target influential antecedents of adaptive responses to heat risks. The paper makes three important contributions. First, it organizes literature on the antecedents and behavioral responses to heat risk; second, it provides a typology of the range of heat risk behaviors; and, third, it discusses how antecedents can be integrated into communication interventions. The review concludes with a proposed agenda for research, highlighting the need for substantial testing and evaluation of heat risk communication, applying insights from the literature.

This article is categorized under:

Perceptions, Behavior, and Communication of Climate Change > Communication

Perceptions, Behavior, and Communication of Climate Change > Behavior Change and Responses

KEYWORDS

antecedent, behavior, communication, framing, heat risks

1 | INTRODUCTION

The most immediate and direct impact of a warming climate on people's health results from rising temperatures, and the increased frequency, intensity, and duration of extremes of heat (Watts et al., 2019). The IPCC (2022) has warned that due to climate change, the percentage of the global population exposed to heat stress is projected to increase from around one in three today, to 48%–76% by the end of the century. Furthermore, most populations now live in cities that have amplified risks due to "urban heat island" effects (Keith et al., 2019), and where hot extremes including heatwaves have intensified, aggravating air pollution events and disrupting infrastructure (IPCC, 2022).

Extreme heat events underpinned by human-induced climate change have resulted in human mortality and morbidity on every continent (IPCC, 2022; Vicedo-Cabrera et al., 2021) and single extreme heat events can lead to thousands of deaths (Mitchell, 2021). For instance, the 2003 heatwave in Europe is estimated to have led to more than 70,000 deaths (Robine et al., 2008). In 2018, there were an estimated 220 million heatwave exposures affecting older populations, while modeling suggests there are 490,000 heat-related deaths each year (Zhao et al., 2021). Other consequences of heat exposure include heat stress, heat stroke, dehydration, accelerated deaths from chronic illnesses (such as cardiovascular disease), increased risk of accidents, impacts to mental health and increased risks of interpersonal and collective violence (Watts et al., 2019; WHO, 2018). The ways in which heat is problematized differ according to places, people, and practices it affects and is influenced by and hence drives the way initiatives are deployed to alleviate the impacts of this risk (Oppermann et al., 2017). Certain populations are known to be at greater vulnerability to extreme heat events, including older people, children, outdoor workers, certain marginalized communities, as well as people who are socially isolated, economically disadvantaged or live with chronic illnesses (Watts et al., 2019; WHO, 2018).

The negative effects of heat on people are predictable and largely preventable, and can rest on people voluntarily taking a range of protective and adaptive actions from going indoors to wearing sunscreen outdoors (WHO, 2018). Heat health action plans (HHAPs) that include warning and response systems are considered to be effective interventions for adapting to extreme heat (IPCC, 2022). Such plans often incorporate heat-health warning systems (HHWSs) and other communication approaches to alert decision-makers and the general public to dangerous heat situations (Casanueva et al., 2019). Several studies have asserted that HHWSs reduce expected mortality to heatwave risks, and can bring economic benefits, for instance, a US study reported that the economic benefits of saving lives (in the order of hundreds of millions of dollars) far outweigh the costs of running warning systems (Toloo et al., 2013a). Studies in different continents have also reported high awareness of heat warnings among the public (Lane et al., 2014; Lefevre et al., 2015) and participants in a UK-based study, who had heard heat protection recommendations reported stronger intentions for implementing heat protection behaviors in the future than those who had not (Lefevre et al., 2015). However, despite widespread use, there is limited evidence that HHWSs deliver intended outcomes. Eight studies have shown that mere availability of heat warning systems does not lead to behavioral changes, and while awareness of heat and heat-related dangers was high, particularly among older age groups, such awareness did not necessarily translate into adaptive behavior, suggesting a "warning-behavior gap" (Toloo et al., 2013a). In the United Kingdom for instance, a major evaluation of the Heatwave Plan (HWP) for England found that there was no evidence the plan was reducing summertime vulnerability to heat risks (L. Williams, Erens, et al., 2019).

Broadly speaking, there are now calls for heat risk management and communications to better incorporate socio-cognitive insights and apply co-production approaches in ways that can change behavior and attitudes (Howarth et al., 2019). In this review, we focus on how insights from behavioral-focused studies of heat risk engagement among the public can be translated into better communication about heat risk. We address the following question: "How can heat risk communications, which aim to increase adaptive behavioral responses, be improved through examination of behavioral science and social science insights?"

1.1 | Heat risk behavior: The three spheres framework

We first conceptualize and discuss three spheres of heat risk behavior (Figure 1), before reviewing the impact of heat risk communication specifically. We define the innermost "behavioral" sphere as covering a range of actions and responses that individuals might take in relation to the heat risks posed by climate change (a typology of behaviors is discussed below, adapting previous frameworks). Two spheres of antecedents which influence the behavioral sphere are then discussed. The individual sphere considers the personal and cognitive level antecedents of heat risk behavior (such as knowledge and awareness, emotions and threat appraisals); while the contextual sphere covers external and social antecedents, including demographics, social influences, and policy. We then focus on how communications, a key contextual antecedent, may be improved through incorporating social and behavioral science insights relating to these three spheres.

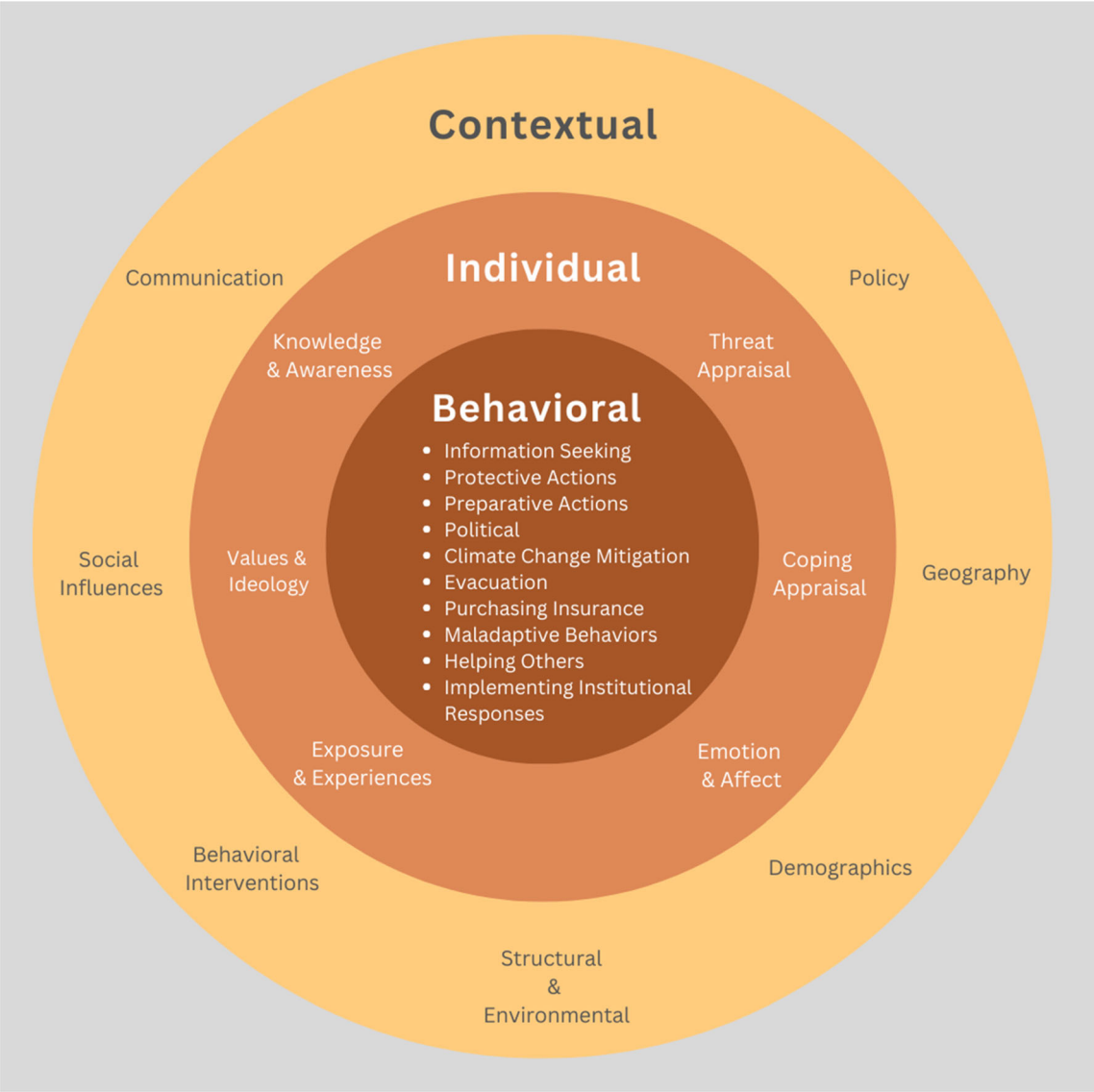

FIGURE 1 The three spheres framework of heat risk behavior. At the center is the "behavioral" sphere, covering the types of actions that can be taken in response to heat risks, with antecedents of action described in middle and outer layers. The middle, "individual" sphere covers personal, affective, and cognitive antecedents of heat risk behavior. The outer "contextual" sphere covers contextual factors influencing the "individual" and behavioral layers.

1.2 | Approach to this review

This review provides coverage of the factors and influences of heat risk behavior—however, it does not seek to be exhaustive. Literature was identified on the basis that it provided evidence on the topic of behaviors (and where relevant perceptions or policy) relating to heat risks, and provided insights about communicating heat risks. Quantitative, qualitative, and mixed methods sources were included. The exclusion criteria were that "evidence was not provided on the topics of communicating about heat risks or the antecedents of heat risk behaviour and/or perceptions" and papers published in years pre-2000. Heat risks had to form a substantial focus in the research but did not have to be the sole focus (e.g., papers included could focus on a range of climate change hazards). It was preferable but not essential for papers to make reference to, or attribute heat risks to climate change.

Literature was collected via Clarivate's Web Of Science (WOS), a leading database of citation-indexed research articles, which has extensive coverage of the social sciences. Search terms were shortlisted from a long list of 148 of relevant terms. Searches were piloted and refined iteratively, until a manageable number of papers were returned, with a clear majority of relevant studies. Thirty-six relevant studies were gathered via WOS, using the

search terms relating to heat risks (e.g., heatwave, heat stroke), behaviors, perceptions, and climate change.[1] Three of the papers returned from WOS were removed due to lack of relevance. WOS sources were supplemented with papers already known to the authors, as well as a search for gray literature via Google (using similar search terms) and further relevant papers discovered during the review (e.g., new papers published or highly relevant articles referenced in papers). In total, 62 behavioral and perception-focused studies were reviewed. These were mostly academic journal articles, although the review also included gray literature, policy-related reports, case studies and a relevant thesis chapter. The reasoning for this was that the topic of heat risk communication is a fast-developing area, spanning academia, policy, and practice, and we found that key insights and data sometimes exist outside of academic journals. Relevant academic literature collected spanned several disciplines, including psychological and behavioral sciences, public health, communications studies, geography, sociology, and disaster risk reduction. A small number of physical science, technology, and engineering papers returned did not meet the inclusion criteria. Evidence sources were entered into an annotated bibliography, using a structured template.[2] Data were extracted from quantitative studies that used inferential statistics to address the antecedents of perceptions and behaviors. These data were captured in excel ahead of the write up.

To our knowledge, one related review exists already (Hass et al., 2021). However, while this review did address behavior, communications, and related policy to some extent, the researchers substantive focus concerned heat *perceptions*. They also considered a smaller number of papers (31 rather than >60), and excluded papers published before 2010 as well as gray literature. The current review speaks to several gaps not covered in Hass and colleagues' paper, such as the types of heat risk behaviors considered in research, influences on behaviors, types of models and frameworks, and tailoring of communications.

Nevertheless, while behaviors are of primary interest in this review, due to the well-reported relationship between perceptions and behaviors (see Ajzen, 2011; Fishbein & Yzer, 2003), and given that some studies discussed consider both perceptions and behaviors simultaneously, we acknowledge both these types of outcomes throughout the paper. This approach makes sense in relation to the present topic, as public engagement with climate risks is considered to simultaneously implicate attitudinal, affective, and behavioral components (i.e., what people think, feel and do about climate change—Lorenzoni et al., 2007).

As there is no universally agreed definition of "heat risks," "heat waves," or "extreme heat," papers have applied heterogeneous approaches in studies. We therefore take a broad view of heat risks as a climate change related hazard where heat poses a direct threat to health. In this review, we do not focus on the secondary impacts of heat risks, such as indirect impacts on people via droughts, wildfires, food security, or influence on air pollution. We also take a broad view of communication in this article but also other complementary forms of communication, such as informational appeals, campaigns, visuals and other forms of public engagement carried out by individuals, businesses, and other organizations. The emphasis in this review is less on channels and modes of communication (e.g., TV, radio, online), and more on what can be learned from the drivers of behaviors and perceptions and evaluations of communications practices. A predominantly socio-psychological perspective is taken in this review, largely due to the type of literature reviewed, drawing on a range of behavior change and risk communication theories. The heat risk communications literature has applied a range of well-known frameworks, such as Health Belief Model (HBM, Janz & Becker, 1984; see Akompab et al., 2013) Protection Motivation Theory (PMT, Maddux & Rogers, 1983; Rogers, 1975; see McLoughlin, 2021), Theory of Planned Behavior, etc. (Ajzen, 1991; see Valois et al., 2020), which typically treat the effects of communications on the individual as the primary focus.

As a first step to designing better heat risk communications, it is important to have a clear picture of types of behaviors that could be taken in response to heat risks, and how far people engage with these behaviors. The following section details the range of behavioral responses that behavioral studies have focused on.

2 | HEAT RISK BEHAVIORS

2.1 | Types of behaviors

A large number of possible behavioral responses to heat risks have been reported in the literature to date. Heat risk responses range from using an indoor air conditioning unit to drinking more water and fluids, to wearing lighter clothing, to adapting the vegetation cover in one's garden. There are many possible ways of categorizing precautionary behaviors, using existing axes—such as egocentric, prosocial, or altruistic actions (e.g., Esplin et al., 2019). However, to

date, there is no overarching typology which has been specifically tailored to categorize heat risk actions and responses into a coherent framework. Given this gap, we provide a typology of heat risk behaviors with examples (see Table 1). This typology adapts and expands upon van Valkengoed and Steg's (2019b) highly relevant categorization of adaptation behaviors, tailoring this to heat risk behaviors.

Across our review, we found that behavioral studies have overwhelmingly focused on protective actions, followed by preparative actions. This emphasis on protective actions is inadequate as it shifts attention away from other behaviors such as seeking to influence policy or structural approaches that may be more beneficial to a greater number of people over time. Other types of responses, such as political actions, purchasing insurance, or evacuation were less commonly studied. As part of the focus on protective behavior, many behavioral studies to date have focused on air conditioning use as an outcome of interest. This is notable because while air conditioning use can reduce morbidity to heat risks, it has been described as a "double edged sword" and a form of "maladaptation" as it can lead to energy usage spikes, exacerbate climate change by increasing greenhouse gas emissions, and contributes to urban heat island effects (Barnett & O'Neill, 2010; Watts et al., 2019). This speaks to a broader discussion on the importance of better integrating measures for climate adaptation (e.g., increasing resilience to heat risk) with those for mitigation (e.g., installing energy efficiency measures). The complexities of protective behavioral responses highlighted in this review demonstrate the wide range of approaches that may be of increasing policy relevance.

2.2 | Engagement in adaptive behaviors

While there is evidence of widespread adaptive behaviors in response to heat risks in certain countries, the picture is complex. In the United Kingdom for instance, there are reportedly high levels of awareness about the actions to take during heatwaves (e.g., Khare et al., 2015). Studies in other regions also report high adoption of adaptive responses—for instance, Akompab et al. (2013) found that 82.8% of respondents in Adelaide, Australia ($N = 267$) reported "good adaptive behaviors" for heatwaves. However, there is conflicting evidence about behavioral engagement, for example, whether vulnerable populations (e.g., low-income groups and residents in cities) are more or less likely to take actions, despite generally having higher risk perceptions (Akompab et al., 2013; Khare et al., 2015). Furthermore, while the public may recognize the effectiveness of some actions (e.g., drinking fluids, staying out of the sun during the day), they may not appreciate the effectiveness of other actions (e.g., closing windows in direct sunlight, or avoiding alcohol) (L. Williams, Erens, et al., 2019).

3 | ANTECEDENTS OF HEAT RISK BEHAVIORS

Many antecedents of heat risk behaviors and perceptions have been documented in research to date, ranging from risk perception, awareness of heat risks and perceived costs of action, to household income, employment, and marital status. Table 2 provides a breakdown of over 45 factors in the individual and contextual spheres, which have been associated with heat risk behaviors (and perceptions) in studies reviewed. Individual antecedents include threat appraisals (e.g., awareness of heat risks, perceived vulnerability/severity), coping appraisals (e.g., self-efficacy, perceived behavioral control), attitudes, beliefs, and knowledge (e.g., knowledge about heat risks, pro-environmental values), past experiences (e.g., past experience of heat risks, past behavior), emotions/affect (e.g., sense of fear or dread). Contextual factors include social influences (e.g., persuasion, social norms), structural factors (e.g., ambient temperature, housing type), geography (e.g., region, rural, urban), communication (e.g., HHWSs, campaigns), policy and other interventions (e.g., HHAPs). These factors are discussed below in greater detail. Many of the factors, especially those at the individual level, make sense in relation to existing behavioral theory, noted earlier, such as HBM, PMT, TPB, as well as theory relating to the communication of health risks (see Fishbein & Yzer, 2003).

Many behavioral studies rely on self-reported data and therefore measure behavioral intentions (i.e., willingness to take an action), rather than real behavior. While this has limitations, intentions nevertheless have a substantial effect on actual heat risk behavior (Valois et al., 2020, for instance, report an effect size of $\beta = 0.463$, $p < 0.01$). Since intentions directly pertain to, and are often used as a proxy for a given behavior, they are not included as an antecedent in the table, but instead are considered as an outcome variable that may be influenced by the factors presented.

The following sections will provide discussion of factor categories. Antecedents for specific types of behaviors (as distinguished in Table 1) are discussed where possible; however, most quantitative studies have measured adaptive

TABLE 1 Typology of heat risk behavioral responses

Category	Definition	Examples (source)
Information seeking	Expending time and effort to gain more information about heat-related risks, to identify one's risks, and gaining information about how to successfully adapt to heat risks	"Read about how to avoid heat stress during heatwaves" (Steentjes et al., 2020) "Watch weather forecasts" (Zhou et al., 2014) "Concern about health protection guidelines" (Ban et al., 2019)
Preparative actions	Structural actions taken before the onset of heat risks aimed at reducing the probability of being affected by heat risks, or minimizing the negative impacts of heat.	"Installing loft insulation" (Kent et al., 2013) "Having shutters" (Khare et al., 2015) "Getting fans, shades, umbrellas in garden" (Abrahamson et al., 2009)
Protective actions	Actions taken during heat risk events to avoid or reduce its impact	"Drinking water/fluids" (L. Williams, Erens, et al., 2019) "Turning on a fan" (White-Newsome et al., 2011) "Decrease activity" (Liu et al., 2013) "Use air conditioning at home" (Esplin et al., 2019)
Purchasing insurance	Purchasing an insurance policy that covers the negative outcomes of heat risks	"Medical insurance" (Huang et al., 2018)
Political actions	Influencing local or national government to implement policies aimed at reducing heat risks, including policies to mitigate and adapt to climate change	"Introducing tight regulations on buildings to be able to deal with hotter and drier weather (e.g. insulation, air-conditioning)" (Steentjes et al., 2020) Support for "Reducing carbon emissions to net zero by 2050" (Steentjes et al., 2020) "Upgrading our homes and buildings to be better insulated" (Kotcher et al., 2021)
Climate change mitigation	Individual or household actions that aim to mitigate climate change, for instance, by reducing greenhouse gas emissions	"Reduce flying for holidays" (Steentjes et al., 2020) "Eat less meat" (Steentjes et al., 2020)
Evacuation	Temporarily moving away from an area to avoid the negative impacts of heat risks; may also include leaving an area permanently if required	"Go to a cooler place" (L. Williams, Erens, et al., 2019) "Go to public place with air conditioning" (Liu et al., 2013) Leave home and go to a cooler place (Esplin et al., 2019)
Maladaptive responses	Doing nothing to reduce one's heat risks despite awareness, actions that increase one's risk, and/or expose others to greater vulnerability	"Did nothing different" (Hass & Ellis, 2019b) "Did not do anything differently" (L. Williams, Erens, et al., 2019) "Do some outdoor gardening during the day" (Akompab et al., 2013)
Helping others	Helping or protecting others or acting in ways such that other people are better placed to respond and adapt to heat risks	"Communicate heatwave alerts to other staff" (L. Williams, Erens, et al., 2019) "Ensure patients/clients and their carers have the required information on how to protect themselves" (L. Williams, Erens, et al., 2019) "Persuade relatives or friends to reduce their carbon emissions" (Steentjes et al., 2020)
Implementing institutional responses	Actions taken to implement or deliver institutional or business responses to heat risks	"Implement business continuity" (L. Williams, Erens, et al., 2019)

(i) Types of behaviors adapted from van Valkengoed and Steg (2019b). (ii) Please note, as discussed in this review, AC use may also be considered a form of maladaptive response in this framework, where appropriate.

behavioral responses to heat risks at an aggregate level, by combining several types of behaviors into a single metric (e.g., "Adaptive behaviour during heatwave," "Intentions for future heat protection behaviours," etc.). Therefore it is not always possible to distinguish the relationships between antecedents and specific behaviors. The table also indicates where quantitative studies have found significant effects for the factors on behaviors and perceptions. This is intended to add further information about the salience of these factors according to existing evidence and help to clarify which factors appear to have dual influences on both behaviors and perceptions.

TABLE 2 Factors that influence heat risk behaviors and intentions according to literature reviewed (in both quantitative and qualitative studies)

Sphere	Antecedents	Examples of factor(s) (noting that not all factors are mutually exclusive)
Individual	Knowledge and awareness	• Knowledge about heat risks[a] • Awareness of heat risks • Perceived changes in weather events[a]
	Threat appraisal	• Risk perception[a,b] • Perceived susceptibility/vulnerability[b] • Perceived severity[b] • Ability to form mental imagery of climate hazards[b]
	Coping appraisal	• Self-efficacy (i.e., feeling personally able to act)[b] • Response efficacy (i.e., perceived effectiveness)[b] • Perceived costs of the action[b] • Perceived barriers to action • Perceived behavioral control (i.e., ability to control and influence a behavioral outcome) • Locus of control (i.e., attribution of life events to internal or external factors)[a,b] • Attitudes toward heat risk behaviors[b]
	Exposure and experiences	• Prior experience of heat risks[a,b] • Exposure to heat risks[a,b] • Past behavior[b] • Perception about personal sensitivity to heat[a]
	Emotions/affect	• Positive/negative affect[b] • Concern about heat risks[a,b] • Concern about climate change[b] • Fear • Dread[b]
	Values and ideology	• Pro-environmental values[a] • Political ideology
Contextual	Social influence	• Descriptive social norms (i.e., commonness of attitudes and behavior)[b] • Persuasion by others like key messengers (e.g., doctor's advice to take action) • Family influences[a,b] • Visit from health worker[a]
	Demographics	• Age[a,b] • Sex and gender[a,b] • Education level[a,b] • Employment (status, level, and type)[a,b] • Household income[a,b] • Health (e.g., past or existing medical conditions)[a] • Marital status[a] • Living arrangements (e.g., living alone, or with others) • Student status[b] • Family size[a]
	Structural/environmental	• Ambient temperature (indoors and outdoors)[b] • Season • Housing type[b] • Housing insulation[a] • Hot and dry weather • Access to appliances (e.g., fan, air conditioning unit)[a]
	Geographical	• Region • Urban/rural location[a,b]

(Continues)

TABLE 2 (Continued)

Sphere	Antecedents	Examples of factor(s) (noting that not all factors are mutually exclusive)
		• Amount of time spent in hotter regions[b]
	Communications, policy and behavioral interventions	• Heat/heatwave action plans and policy frameworks • Heat risk warning systems[b] • Heatwave education[b] • Public information programs • Campaigns • Public engagement • Cues to action[b] • Media coverage of heat risks • Imagery (e.g., in the media) • Attribution of heat risks to climate change

Note: Indications of significant associations with heat-related behaviors ([b]) and perceptions ([a]) are indicated, according to quantitative studies reviewed, where this information was available. This table does not include "behavioral intentions" as an antecedent, as this is often considered as an outcome variable, or proxy, to measure real world behavior in studies reviewed. Further, while some quantitative research breaks down the influence of factors on specific types of behaviors/intentions (e.g., drinking more water, or, going outdoors), many studies reviewed measured aggregate level outcome variables (e.g., willingness to adapt to heat) which considers multiple types of behaviors/intentions together. Due to this, we do not specify the links between specific factors and categories of behavior in this summary table and recommend reviewing supporting references for this information. Please note that factor names may be reported and categorized differently in original sources.

[a]Significant association between factor and heat-related perception reported in quantitative papers reviewed (Akompab et al., 2013; Ban et al., 2019; Beckmann & Hiete, 2020; Hass & Ellis, 2019a; Huang et al., 2018; Madrigano et al., 2018; Rauf et al., 2017; Tawatsupa et al., 2010; Taylor et al., 2014; L. Williams, Erens, et al., 2019).

[b]Significant association between factor and heat risk behavior/behavioral intention reported in quantitative papers reviewed (Akompab et al., 2013; Ban et al., 2019; Esplin et al., 2019; Hass & Ellis, 2019b; Lefevre et al., 2015; Liu et al., 2013; Madrigano et al., 2018; McLoughlin, 2021; Mishra et al., 2009; Rauf et al., 2017; Valois et al., 2020; White-Newsome et al., 2011).

3.1 | Individual sphere antecedents

3.1.1 | Knowledge and awareness

Having knowledge and awareness of heat risks is an important precursor of action. In southeast India, heatwave education and knowledge of protective actions were found to significantly facilitate flood and heatwave preparedness (Mishra et al., 2009). However, mismatches in expert and lay-people's knowledge about heat risks have been documented. For instance, adopting a mental model approach, Chowdhury et al. (2012) detail mismatches in Canadians' perceptions about the effects of heat risks, understanding of underlying physical processes, responsibility of authorities, role of ozone thinning, and effectiveness of precautionary measures. Knowledge of heatwaves can also underpin perceived threats (Beckmann & Hiete, 2020), which in turn may influence behavior, as discussed next.

3.1.2 | Threat appraisals

Threat appraisals, including risk perceptions and perceived vulnerability, are some of the main factors reported to be associated with heat risk behaviors. In a review of heat warning studies, perceived threat of heat to oneself and others was the main factor related to heeding warnings and responding adaptively (Toloo et al., 2013b). Studies have found that awareness of heat risks, alone, is insufficient to induce a response, with those perceiving vulnerability more likely to engage in protective actions (Abrahamson et al., 2009; Sheridan, 2007; Wolf, Adger, Lorenzoni, Abrahamson, & Raine, 2010). However, the relationship between threat appraisals and adaptive behavior may vary with different types of responses (Esplin et al., 2019). Furthermore, not all studies find a significant relationship between risk perception and behavior, suggesting high-risk perceptions alone do not reduce risk and other factors need to be taken into consideration (Akompab et al., 2013; Liu et al., 2013).

There is some evidence that threat appraisals about heat risks have shifted in some countries. Comparing UK national survey data, Steentjes et al. (2020) find most measures of heat perceptions have seen significant increases in recent years. In 2013 only 23% of respondents thought heatwaves were a "fairly or very serious problem," but this had

increased to 72% in 2019. In 2013 only 33% of respondents thought heatwaves would be more common in 2050, but in 2019 this had increased to 77%. However, there is conflicting evidence, with Taylor et al. (2014), reporting that people in the United Kingdom felt heatwaves and hot summers were becoming *less common*. There is also evidence that perceived vulnerability to heat risks is lower among the UK public than for other climate hazards in the United Kingdom (e.g., air pollution, flooding, and new/emerging infectious diseases) (McLoughlin, 2021; McLoughlin & Corner, 2020). It is possible that the timing of data collection may have affected these results, as Steentjes and colleagues collected data after the 2019 UK heatwaves, while the other studies were carried out in winter-to-springtime; although methodological differences (e.g., question framing and type of analysis) may also account for discrepancies.

3.1.3 | Emotion/affect

The importance of emotions (short term, sometimes complex, feelings such as joy or fear) and affect (longer term states of feeling encompassing emotions and moods) have been reported in some studies. For instance, Ban et al. (2019) found that perceived fear, dread, and concern mediated the relationship between exposure and different heat-related behaviors in China. Similarly, through qualitative research, Hansen et al. (2011) found that psychological issues including fears and anxieties about extreme heat influenced the ability of older Australians to adapt to hot conditions. In this sense, evidence of a baseline emotional shift related to heat risks in some countries is significant. In 2013 only 29% of UK national survey respondents expressed concern if hot summers became more common, though by 2019 this proportion had increased to 66% (Steentjes et al., 2020). However, while emotions can strongly influence behavior, there is evidence in the United Kingdom that the public tend to hold positive views about hot weather (L. Williams, Erens, et al., 2019) and concern is lower for heat-related risks compared to other climate hazards (McLoughlin, 2021). Given this, scholars have noted that positive associations with hot weather in certain countries can act as a barrier to adaptation, while communication about heat risks is undermined by evoking positive affect—and warnings may therefore need to evoke greater negative emotions (Lefevre et al., 2015; O'Neill, 2019).

3.1.4 | Coping appraisals

Coping appraisals are people's evaluations of responses to hazards, and include variables such as sense of efficacy (i.e., ability and effectiveness), sense of control, perceived benefits, and perceived costs of action. In the context of heat risks, several studies document influences of coping appraisals. For instance, sense of control has been shown to influence responses in different ways—an individual's perceived behavioral control (i.e., perception of control of the behavior) can influence heat-related behaviors (Valois et al., 2020), while having an "external locus of control" (i.e., believing events occur due to external influences, rather than one's personal control) can undermine preparedness, even with prior experience of heatwaves. Perceived costs and benefits also play a role—for instance, studies in Australia and Pakistan have shown that individuals are more likely to behave adaptively when there are perceived benefits (Akompab et al., 2013; Rauf et al., 2017). On the other hand, the costs of actions (e.g., financial costs of installing or running cooling equipment) have frequently been cited as a barrier to action—leaving people at greater risk (Hass & Ellis, 2019a; Lane et al., 2014; Soebarto et al., 2019). The affordability of heat risk adaptation has a clear association with demographic factors here (see below).

Several other types of coping appraisals also bear influence. A UK study has demonstrated an influence of self-efficacy (i.e., perceived ability to act) and response-efficacy (i.e., perceived effectiveness) on adaptive responses, alongside other antecedents (McLoughlin, 2021). Despite this, there may in some cases be an "effectiveness-action gap." In one study, even though some behaviors were seen as effective, this did not mean they were carried out by the individuals (Khare et al., 2015). This makes sense in reference to health psychology and climate adaptation studies, which suggests coping appraisals are necessary alongside threat appraisals to promote adaptive responses to hazards (Peters et al., 2013; van Valkengoed & Steg, 2019a; Witte & Allen, 2000). For instance, the influence of perceived response effectiveness appears to be mitigated by peoples' perceptions of risk, such that individuals who do not perceive themselves to be at risk are less likely to take protective actions they know to be effective (L. Williams, Erens, et al., 2019). This aligns with evidence that action is motivated by heatwave warnings when they influence perceived effectiveness (Lefevre et al., 2015) and when climate messages appeal to both threat and coping appraisals (Kotcher et al., 2021; McLoughlin, 2021; McLoughlin & Corner, 2020).

3.1.5 | Exposure and experiences

Personal experiences of heat risks and past actions can influence the likelihood of adaptive behavior. For instance, exposure to heat hazards is found to influence behaviors in China (Ban et al., 2019) and India (Mishra et al., 2009). The type of exposure may matter—Esplin et al. (2019) report that experience of heat health symptoms was a stronger influence on protective behaviors than other measures of heat exposure. Exposure influences can also be variable. Perceptions and behaviors can vary during heatwave events, and people are not necessarily consistent in their actions on similarly hot days that do not occur during an extended heatwave (Lam et al., 2018). Interestingly, exposure to, and experience of, heat can also influence beliefs about global warming (Joireman et al., 2010) and the belief that one has experienced climate change personally (Marlon et al., 2021), which in turn may influence behavior.

3.1.6 | Values, ideology, and worldviews

There is fairly limited evidence that worldviews and values (i.e., guiding beliefs and goals) directly influence heat risk behaviors. However, political values appear to interact with exposure and experience (discussed above) to influence climate change beliefs, which may in turn influence engagement with heat risk adaptation. For instance, Marlon et al. (2021) found that Democratic Party affiliation and liberal ideology were substantially stronger predictors of perceived experience with global warming, compared to participants' exposure to hot dry days. There is evidence that language framings interact with worldviews here. One study looked at effects of heat-related cues (e.g., images, such as a university campus in different seasonal conditions) on people's belief in "global warming" versus "climate change," finding interactions with political ideology (Schuldt & Roh, 2014). An "unseasonably warm prime" led to significantly lower belief in "global warming" among participants with low environmental concern but higher belief among participants high in environmental concern. The beliefs of more politically liberal participants, however, were unaffected by the weather primes. Furthermore, in a US survey, political conservatives were less likely to say they would prepare an emergency kit in response to "climate change" than to "extreme weather" (Carman et al., 2021). This suggests the way that heat risks are framed in relation to climate change can be influential for groups who tend to be more skeptical of climate change.

3.2 | Contextual sphere antecedents

3.2.1 | Structural and environmental factors

A range of infrastructural and environmental factors, such as access to an AC unit or fan, can act to enable or prevent individual and household action on heat risks (Porter et al., 2014). Structural factors can also shape decision-making in contexts where protective behavior is common. In a study where older individuals were asked to record an hourly log of actions, the availability of infrastructure (e.g., air conditioning or basement) had a clear influence on the type of behaviors people carried out—such as utilizing equipment, drinking fluids, or changing clothing (White-Newsome et al., 2011). Access to appliances can also influence risk perceptions, increasing a sense of protection from negative health impacts (Akompab et al., 2013). However, there are clear examples of inequality in access to protective appliances such as cooling units, associated with ethnicity and affordability (e.g., Madrigano et al., 2018). In turn, researchers have called for heat-adaptation policy initiatives to include direct support for structural improvements (Wolf, Adger, & Lorenzoni, 2010).

3.2.2 | Geographical factors

Numerous studies show geographical and regional variations exist in heat risk behaviors and perceptions. Some studies suggest associations between heat adaptation and exposure to hot weather. For instance, in the United States, regional variations and a north–south divide are associated with predominant temperatures (Howe et al., 2019). Sometimes, geographic differences in actions are striking. In a large-scale UK survey, residents in Scotland and Northern Ireland were at least 80% less likely to avoid the sun during peak hours or walk in the shade, compared to respondents from the

South of England; and people in Scotland were 70% less likely to use an electric fan (Khare et al., 2015). At a smaller scale, given the risks of overheating are generally greater in urban areas, one might assume that urbanites are more likely to engage in adaptive behaviors. However, evidence of an urban versus rural divide is inconsistent—risk perceptions were found to be higher in US urban areas, where social vulnerability and exposure is higher (Howe et al., 2019), while research in Nanjing, China found rural respondents more likely to take precautionary health measures (Huang et al., 2018). This points to the issue that geography and resulting exposure to hot weather is often not fully explanatory of behavior, and to make sense of spatial influences researchers often must also address demographic and perceptual differences. For instance, Esplin et al. (2019) found that while spatial differences in the United States were evident (e.g., Californians were less likely to use air conditioning, or "check on others" during heatwaves), geography and physical exposure had little influence in predictive models. Instead, Americans' heat adaptive behavior was better explained by risk perceptions, experience of health impacts, and demographic factors such as age, gender, and ethnicity. In this sense, planners must unpick the complexities of heat adaptation at different geographic scales to inform intervention design (Esplin et al., 2019).

3.2.3 | Demographics

Several studies report variations in behavior and perceptions of heat risks to be associated with demographic factors, such as age, ethnicity, household income, education level, and gender (Akompab et al., 2013; Hass & Ellis, 2019b; Liu et al., 2013; Rauf et al., 2017; Tawatsupa et al., 2010; S. Williams, Hanson-Easey, et al., 2019). In the United States, certain vulnerable populations, such as poorer neighborhoods and minority populations have been reported to have higher heat risk perceptions, consistent with exposure (Howe et al., 2019). Yet the picture is complex, as inequalities in access to protective infrastructure exist due to income and ethnicity (Madrigano et al., 2018) and there also appears to be some paradoxical findings. For instance, while the elderly have greater vulnerability, a number of papers suggest elderly are *less* likely than younger people to take some protective measures, or to report heat-related illness (Beckmann & Hiete, 2020; Howe et al., 2019; Khare et al., 2015; Lane et al., 2014). This suggests that the most vulnerable may not always realize they are vulnerable, and their action to adapt to heat risks is limited. Other factors, such as living with others or being married can influence threat appraisals about heat, but these factors do not necessarily translate into behavior (Akompab et al., 2013). In turn, some studies have found no influence of demographic or circumstantial factors—such as income, education level, or living alone—on engagement with heat risks (Beckmann & Hiete, 2020). Again, this suggests that demographics alone do not paint the full picture, and other antecedents must be considered.

3.2.4 | Social and cultural influences

Social influences, including social norms and social persuasion, are well-documented influences on behavior, and have been reported in heat-related studies. For instance, cues to action from medical professionals (i.e., advice to take precautionary measures) were associated with good adaptive behavior in Australia (Akompab et al., 2013), while social norms (i.e., commonness of heat adaptive behavior) were found by Valois et al. (2020) to significantly influence intention to adapt to heat risks, alongside other attitudes and perceived control. Another study has reported influences of social norms on adaptive behavior (e.g., information seeking, protective, preparation, mitigation, and political action) in response to multiple climate health risks, including heat stress (McLoughlin, 2021). Appeals to social norms are therefore advised in communication about climate hazards, such as heat risks (Kotcher et al., 2021; McLoughlin, 2021). Certain demographic factors, such as marital status and household characteristics, may also represent social influence on heat risk behavior. In addition to this, cultural influences may also play a role in shaping behaviors—for instance, different practices relating to food preparation and clothing can sometimes implicate heat responses (Hansen et al., 2011), while moving to a new location can entail localized cultural adaptations to heat (Strengers & Maller, 2017).

3.2.5 | Communication, policy, and behavioral interventions

Several studies discuss and highlight the importance of communication interventions for encouraging adaptive heat risk behaviors (Casanueva et al., 2019; Corner et al., 2020; Lefevre et al., 2015; L. Williams, Erens, et al., 2019; Wolf,

Adger, & Lorenzoni, 2010). Policy measures (e.g., HHAPs, emergency response management) have also been critically discussed as necessary, but frequently limited precursors to action (Casanueva et al., 2019; Keith et al., 2019; Wolf, Adger, & Lorenzoni, 2010). Other behavioral interventions have been discussed less frequently in this context, such as cues to action from health professionals (Akompab et al., 2013). This is interesting as other behavioral interventions, often studied in relation to environmental behaviors, could have relevance here—including goal setting, social norms interventions, implementation intentions, nudges, rewards, and so on (Steg et al., 2013; Stern, 2019; van der Linden & Goldberg, 2020).

The role of the media and journalism in communicating heat risks is increasingly discussed in the literature too. For instance, Painter et al.'s (2021) analysis of around 2500 online news media articles about summer heatwaves in France, Germany, the Netherlands, and the United Kingdom, found that some outlets gave considerable attention to issuing practical advice—suggesting a direct role of the news media for behavioral engagement. However, the analysis also shone a light on the extent to which the media have misrepresented and underplayed the risks of heat—with nearly 90% of the articles covering the heatwave across all four countries not mentioning any link with climate change. This resonates with other recent work, which has highlighted problematic representations of heat risks in the news media (e.g., O'Neill et al., 2022; see also section on imagery below). However, it contrasts somewhat with other research which looked at changes in coverage. Hopke (2020) found that between 2013 and 2018, mentions of climate issues have increased in media coverage of heatwaves and wildfires in five regions (United Kingdom, United States, Europe, Canada, and China). While such media analyses have not measured behavioral outcomes directly, they highlight how the media is likely to have important implications for audiences' engagement with heat risks on attitudinal, emotional, and behavioral levels by conveying heat-relevant information.

In the following section, we discuss the implications of behavioral studies for communications and public engagement specifically, including further discussion of media communicators.

4 | COMMUNICATIONS: INTEGRATING SOCIAL SCIENCE INSIGHTS TO FACILITATE ADAPTIVE HEAT RISK BEHAVIORS

With a clearer picture of the types of behaviors that can be taken in response to heat risks as well as the antecedents of heat risk behaviors and perceptions, we now consider insights on the characteristics of communication interventions, and how insights from behavioral studies may influence their efficacy.

4.1 | Messengers and audiences: Reaching people effectively with heat risk communications

The importance of tailoring and targeting heat messages to different audiences, vulnerable groups and responding to key stakeholder needs has been highlighted by numerous scholars (e.g., Abrahamson et al., 2009; Casanueva et al., 2019; Howarth et al., 2019). While vulnerable groups, such as the elderly, may be obvious priorities for heat risk communication, other audiences can help to reach them, acting as intermediaries. For instance, in applying a tailored communications framework, one study selected "mobile nurses" as the focus of heat risk communication interventions, in order to reach elderly audiences (Grothmann et al., 2017). This is because it may be more effective to target communications towards intermediary audiences who have the ability to reduce the vulnerabilities of more people. People in positions of authority, who can influence the agency of groups of people to respond to heat risks may also be well placed to communicate heat risks and help vulnerable people prepare. For instance, one study highlighted the important role of managers of bus drivers' in accelerating heat adaptation in China (Zhou et al., 2014).

At present, when employing HHWSs, different countries' messaging strategies target different groups and intermediary communicators to reach vulnerable audiences (Casanueva et al., 2019; Toloo et al., 2013b). For instance, warnings are differently targeted in England (National Health Service, local authorities, social care, other public agencies, professionals working with people at risk, individuals, local communities, voluntary groups) to warnings in North Macedonia (retirement homes, General Practitioners, workers). This raises an important question about the types of communicators and messengers that may be best placed to administer information about heat risks. Survey research has found that the UK public tend to trust information about climate change from climate scientists and certain official bodies (e.g., Met Office) more so than campaign groups, the media, and journalists (Steentjes et al., 2020), although the places

people seek information is not always aligned with trust. This underscores the importance of climate specialists, as well as other types of messengers too. As an example, weather presenters and journalists may be particularly appropriate heat risk communicators, given they engage with the public frequently, have unique skill sets to engage audiences, and often have a larger reach than other types of communicators. In turn, there is now a need to place greater emphasis on training different types of communicators to engage audiences on climate resilience issues, including heat risks—and existing projects can act as useful models here. For instance, the Climate Matters project program was developed in the United States to support TV weathercasters, journalists, and local climate educators with resources and training to more effectively inform their audiences about the local relevance of climate change (Maibach, 2021), while specialist climate engagement organizations have sought to equip members of existing networks, such as the Women's Institute in the United Kingdom, with the skills for heat risk communication (Shaw, 2019). However, no studies to date have yet tested experimentally how far different "messengers" *influence* reception of heat risk interventions, and quantitative evidence here could usefully identify which groups are the most trusted or effective when communicating about heat risks specifically, in terms of effects on attitudinal, behavioral, and other key outcomes.

There is also often more that can be done to reach people at risk and to tailor interventions appropriately, integrating research findings. For instance, researchers have noted the importance of presenting warnings in multiple languages, to ensure tourists are reached during summer seasons (Casanueva et al., 2019; Morabito et al., 2019), as have the impact of artistic representations at engaging different audiences (see Hawkins & Kanngieser, 2017). Furthermore, in qualitative studies, elderly respondents identified several creative methods to reach them more effectively, including storylines in soap operas, late-night radio shows, and eye-catching leaflet designs. Communicators may therefore benefit from greater involvement of stakeholders to identify trusted messengers, language, visuals, and communications channels that are highly tailored, while educating and empowering those involved (Abrahamson et al., 2009; Grothmann et al., 2017; McLoughlin, 2021; Shaw, 2019).

4.2 | The message: Effective framing for the communication of heat risks

Communications about heat risks do well to appeal to dynamic socio-psychological factors, to help facilitate behavior (Corner & Clarke, 2017; Klöckner, 2015; McLoughlin, 2021). However, there is currently little existing literature which has directly tested different message framings and narratives that target different antecedents of adaptive heat risk behaviors and perceptions. Many studies infer insights for communications from evidence, rather than testing communications and assessing their causal effects. For instance, drawing on quantitative evidence about the role of emotion Lefevre et al. (2015) report that messages framed to induce greater levels of negative affect may make them more influential. And, following a national survey in the United Kingdom, Corner et al. (2020) highlight the importance of appealing to social norms, a sense of efficacy, and motivational values.

A small number of studies have experimentally tested messages about heat risks alongside messages about other climate hazards (Kotcher et al., 2021; McLoughlin, 2021) with commonalities in that they suggest heat risk messages should communicate the personal threat of impacts, include aspects focused on solutions, appeal to action, and highlight social norms. Nevertheless, further variables may be appealed to, to motivate heat behaviors. Using insights from the behavioral literature reviewed, a set of example messages have been created, to illustrate how communicators may target some of the key antecedents of heat risk behaviors (Table 3).

4.3 | Imagery and visuals

In terms of visuals and imagery of heat risks, analysis suggests that there is a strong disconnect between visuals around summer heatwaves and heat risk messaging in the media (O'Neill, 2019; O'Neill et al., 2022). Often heat risk imagery employs positive imagery (e.g., people enjoying the sun on beaches), which undermines the seriousness of the message. This appears to be supported by some further evidence. One study found that compared to three other climate risks, most heat risk imagery was viewed as less concerning than other impact imagery (McLoughlin, 2021; McLoughlin & Corner, 2020). In this study, heat risk information and imagery led to the lowest feelings of perceived susceptibility of four climate risks in the United Kingdom. Research has also suggested that heat risk messages must increase a sense of negative affect (i.e., negative emotions) (Lefevre et al., 2015).

TABLE 3 Examples of messages framed to target socio-psychological antecedents of adaptive heat risk behaviors and perceptions

Antecedent	Example targeted messages
Perceived benefits of action	Taking actions to protect yourself from heat risks can bring substantial benefits, from remaining cool during heatwaves, to reducing your risk of heat stroke and other illness. Actions can also bring co-benefits. For instance, increasing local tree cover can bring health benefits by reducing air pollution and helping to improve mental health.
Cues to action	Now is the time to take action to protect yourself from heat risks—do not delay.
Self-efficacy	There are many ways in which you have the personal ability to protect yourself from and prepare for heat risks related to climate change. Many actions are simple and easy to implement. You can do this!
Response-efficacy/perceived effectiveness	Preparing yourself for heat risks and protecting yourself during heat risks will be effective. Such actions will greatly reduce the likelihood you and others will face negative health impacts.
Social norms/injunctive/descriptive norms	Growing numbers of people are concerned about heat risks. At the same time, more and more people are taking actions to prepare themselves for heat risks, such as summer heatwaves.
Positive affect about heat (negative directionality)	While in the past we may have looked at summer heatwaves as reasons to feel positive, due to climate change we must now view such events with concern. Heat risks can lead to death and lasting health consequences.
Experience and exposure	Think back to the last time you felt overwhelmed by the heat, perhaps sick or faint with heat stress. This is the reality of heat risks.
Perceived control	While nobody can control when or where heatwave events will strike, we do have control over how well-prepared we are, and what protective actions we take during extreme heat events.
Concern about climate change	The science is settled and there is now a great need to be concerned about climate change impacts. Alarming numbers of extreme heat events are already devastating normal people's lives around the world.
Risk perception	Do not think you are free of personal risk from extreme heat. These types of events can affect anyone, anywhere. Without taking the right precautions, the consequences can include serious health effects and even death.
Attribution to climate change	The types of heat risks we are seeing are being made more likely because of climate change. Human influence is without doubt causing more serious episodes of extreme heat.

Note: These factors have been selected because (a) they are shown to have relatively higher effects on behaviors in quantitative studies reviewed, and (b) they are dynamic—so may be possible to influence through communications alone, unlike static/demographic factors such as ethnicity or housing type. (These messages could potentially be applied in different contexts such as early warning systems, public engagement, or media messaging however their efficacy would be better ascertained through testing via primary research).

Aforementioned study which manipulated photographs of a university campus to show different weather conditions (a "cold prime" and "warm prime") found that imagery was able to influence beliefs in global warming—however, the effects were dependent on individuals' levels of environmental concern (Joireman et al., 2010). Viewing "unseasonably cold" photographs led to significantly lower belief in "global warming" among participants low in environmental concern, while the warm prime had a polarizing effect depending on low versus high environmental concern. Overall, limited research to date has considered the visual dimensions of heat risk messages and communications, despite a growing body of research dedicated to climate change visuals and imagery (e.g., O'Neill, 2013; O'Neill et al., 2013).

4.4 | Attribution of heat risks to climate change

There is limited evidence around the motivational effectiveness of attributing heat risks to climate change to facilitate adaptive responses, although emerging findings suggest this may be important. One study, adopting a sociological approach with data from St. Louis, USA, found that "recipes" of contextual factors promoted discussion about climate change (Boudet et al., 2019). These recipes included community conversation, media stories, and local opinion leaders acknowledging a connection between climate change and heatwaves. Further to this, language used to describe climate risks (i.e., climate change vs. extreme weather) can influence certain types of responses, and this is influenced by

political ideology. In a national US study where participants were asked about perceptions of "extreme weather" versus "climate change," a role of political ideology was apparent (Carman et al., 2021). For collective actions such as participating in preparedness planning, the terms used made little difference for conservatives and moderates. For liberals, however, willingness to engage in these actions was substantially higher when these actions were described as "climate change." However, not all outcomes showed differences between climate change versus extreme weather groups. For instance, a majority in each condition said they were willing to take personal actions such as preparing a home emergency kit. This suggests the language of climate attribution may be crucial for engaging different groups with heat risks. Despite this, there appear to have been some practical and perceptual barriers to greater communication of attribution in the media. Survey research has found that journalists had a relative lack of knowledge about extreme event attribution studies, although they assigned a high level of importance assigned to writing about the link between the heatwaves and climate change (Strauss et al., 2022). This again suggests a need for strategic projects to equip key communicators with the skills to engage audiences with heat risks and their links to climate change.

5 | CONCLUSION

By providing a typology of heat risk behaviors, an overview of the individual and contextual antecedents of heat risk behaviors, and an examination of factors influencing the efficacy of communications, this review has highlighted many opportunities for heat risk interventions, particularly communications, to be improved. However, further research is needed to provide further behavioral and social insights to help improve the effectiveness of policies and interventions. In particular, there is now a great need to more thoroughly test and evaluate heat risk messaging and communication approaches. Only through such research can we fully understand which strategies will save lives and which will not.

To close, we provide an overview of several pressing research gaps, requiring further study:

1. Research evaluating the genuine influence of heat risk warning systems is needed, including analysis of which components are most (and least) effective. This should assess effects on individual-level attitudes and behaviors, as well as the diffusion of information (e.g., across communities or on social media), health benefits, and economic outcomes.
2. Behavioral research should expand focus to include a wider selection of behaviors and responses to heat risks going beyond the overwhelming focus on protective actions. This should include a greater emphasis on high-impact preparative actions and political actions which have the potential to influence behavior in the longer term and beyond one's own capacity.
3. Demonstrating effects of behavioral interventions and communications on real world behavior change is a key gap—many studies focus on behavioral intentions, self-reported information, and perceptions. Thus, there is a need for experimental study looking at causal effects on real world behavior.
4. Further studies are also needed to understand how to improve the transition from intention to adoption of protective behaviors (Valois et al., 2020).
5. Experimental testing is needed to identify what qualities specific messages need to motivate individuals, and which antecedents to prioritize in messaging.
6. Longitudinal study is almost non-existent in this context—most studies analyze people's responses to questions at one point in time. Thus, there is a need for evaluation at more than one time point, and to assess longer term effects.
7. Evidence on how to communicate "variability" and "attribution" in the context of heat risks is lacking, and should be tested directly.
8. Several studies have understandably focused on older persons given their higher vulnerability—however, this has left a need for more research tailored to other vulnerable groups—such as homeless people, drug and alcohol dependents, disabled people, people in poverty, and vulnerable outdoor laborers.
9. There is also relatively less research considering youth perceptions of heat risks, despite the younger generation living with greater risks into the future.
10. Research is needed to test how people respond to heat risk imagery. The assumption that "heat risk imagery should induce negative affect" should be tested in order to validate claims. If this claim is supported, such research has the potential to influence media usage of imagery.
11. It would be worthwhile testing frameworks for heat risk messages highlighted in this review—such as testing messages which combine threat, efficacy, and social norms characteristics.

12. Many studies have been conducted during hot periods—this leaves a gap whereby changes in behaviors and antecedents across the seasons have been left under-researched. Study is needed to understand how effects of interventions may vary throughout the year, perhaps before, during, and after heat risk periods.

AUTHOR CONTRIBUTIONS

Niall McLoughlin: Data curation (equal); formal analysis (lead); investigation (equal); writing – original draft (lead). **Candice Howarth:** Conceptualization (equal); formal analysis (supporting); funding acquisition (lead); methodology (equal); supervision (equal); writing – review and editing (equal). **Ganga Shreedhar:** Conceptualization (equal); formal analysis (supporting); methodology (equal); supervision (equal); writing – review and editing (equal).

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CONFLICT OF INTEREST

The authors have declared no conflicts of interest for this article.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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Artful climate change communication: Overcoming abstractions, insensibilities, and distances

ENDNOTES

[1] The exact search string in WOS was: ((TI=(heat OR heatwave* or "heat risk" OR "heat stress" OR "heat stroke" OR "sun stroke")) AND TI=(attitud* OR percept* OR belief* OR opinion* OR behav* OR appraisal* OR psycholog* OR worry* OR anxiet*)) AND TS=(stress OR vulnerab* OR risk* OR hazard* OR threat*) AND TS=(climat* OR "climate change" OR "global warming") AND TS=(people OR public* OR human*). In WOS, the abbreviations TI = title and TS = topic search.

[2] This template was designed to capture and organize standard features of research papers such as citation, title, aim, methods, results, date of research—as well as elements specific to this project, such as implications for heat risk communication.

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