

Climate Change Impacts on Occupational Health of Indonesian Farmers and Forestry Workers

Knowledge, Risk Perception, Precautionary Behavior, and Communication

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Executive Summary

Challenges

- The Evidence of Climate Change. The Earth's temperature has risen as a result of global warming. The Intergovernmental Panel on Climate Change (IPCC) forecasts that by 2080–2100, the average temperature in tropical regions will rise by 1.6˚ C (in the mid-range emission scenario) and 3.3˚ C (under the high emission scenario), with a margin of error of approximately 0.5˚ C for both predictions. Indonesia, a country located in the tropics, has witnessed climate change, typified by an increase in surface temperature. According to Indonesian Meteorology, Climatology, and Geophysical Agency (BMKG), the daily maximum temperature in Indonesia for the month of July 2022 has reached 38.8˚ C in the Makassar region and 35–36.5˚ C in the Java-Nusa Tenggara region. This rise is significant compared to the highest temperature ever recorded in the same area in 2012.
- Heat Exposure Effect to Human Health. Prolonged heat exposure in humans will result in heat-related illness (HRI) (Kjellstrom et al., 2016; Riccò et al., 2020; Oppermann et al., 2021), and even occupational injuries (Varghese et al., 2018), which generate considerable economic losses, not only in the form of medical costs, but also lower work productivity, quality of life, and even death (Schmeltz et al., 2016).
- Effects on Agricultural Workers. Agriculture, including forestry and its combination, agroforestry, is one of the world's most important industries, and has long been known as one of the sectors hardest hit by climate change (Nelson et al., 2009). There are around 33.4 million agricultural laborers in Indonesia (BPS, 2020), which is equivalent to 12 percent of the country's population. In Indonesia, outdoor workers in the farming and forestry industries are highly reliant on their work to meet their financial demands.
- The importance of this study. When it comes to the Sustainable Development Goals, the international community has pointed to climate change's effects on workers' health and job productivity as a major concern that can threaten the stability of a country (Butler, 2018). However, very little research has been conducted on agricultural workers (especially farmers and forestry workers) in Indonesia, in terms of occupational health.

Purposes

- Research Questions. One of the challenges is the lack of understanding of health behavior changes at the worker level, which needs to be addressed in an effort to formulate health promotion and prevention program strategies to face the threat of HRI. From this point of view, it is important to find out how workers perceive the risks of being exposed to heat as a threat to their health and work. Threats, constraints, and the capacity of workers to take the essential preventive actions must be thoroughly recognized. Additionally important, is to do more research on communication factors since effective communication has a big impact on the success of both top-down (occupational health and safety policy) and bottom-up preventive HRI initiatives.
- Objectives. In order to deal with the unavoidable effects of climate change, the goal of this research was to make outdoor agricultural workers more aware of and better able to deal with the negative effects of rising temperatures in the workplace. To achieve this goal, this study aimed to assess the knowledge, risk perception, and preventive actions of Indonesian farmers and forestry workers about heat exposure. In addition, we investigated the relationship between the three for both categories of workers. Communication is one of the most valuable elements in the implementation of

adaptation techniques. So, another goal of this research was to identify who farmers and forest workers would trust to deliver the adaptation messages, what that messages should consist of, and how it should be delivered. By doing so, a proposed appropriate risk communication plan may be developed.

- Output. The availability of data and information needed to develop strategies for adapting to and preventing problems caused by climate change was the expected output of this research

Methodology

- Participants. This confirmatory cross-sectional study was conducted in Indonesia, utilizing both open-ended and closed-ended questions. The survey included 425 participants aged 15 and older who worked as farmers (215 participants) or forestry workers (210 persons).
- Locus. Cilegon and Serang (Banten Province), Jepara and Blora (Central Java Province), and Cepu (East Java Province) were surveyed between June and August 2022 to gather data. These regions represent the three main rice-producing provinces in Indonesia or have active forestry operations.
- Questions. A minimum of 110 questions were asked among all participants. The questions were separated into eight groups of questionnaires based on their subject matter, i.e., participants' demographics and work descriptions; climate change impact on occupational health and climate change awareness; heat-exposure impact on income; heat-exposure effect prevention actions and training experience; heat-related knowledge; risk perception; precautionary behavior; and communication preferences.
- Data Analysis. Using descriptive statistics, the proportion of data linked to demographics, climate change awareness, the effect of heat in the workplace on income, heat-effect prevention actions and training experience, and communication preferences in both groups of participants were determined. The correlation, mediation, and moderation interactions between components of knowledge, risk perception, and precautionary behavior were investigated by using a Structural Equation Modeling (SEM) with the Partial Least Square (PLS) technique.

Findings

- Climate change effect awareness. According to the findings of this study, heat exposure caused distress among the participants. At the time of the study, participants reported feeling warmer temperatures in the workplace than in prior years. This increased heat exposure was viewed as a threat to their occupational health. Participants have been observed adopting broad-brimmed hats and wearing long, layered, or dark-color outerwear in accordance with their local knowledge. However, some workers are forced to carry on working without access to work huts or closets, despite the fact that these two amenities are a fundamental necessity. According to the findings of this study, workers are unable to bargain for even basic facilities.
- Knowledge, risk perception, and precautionary behavior. This study shows that three of the most important factors in reducing the health impact of heat exposure are knowledge, attitude toward risks (risk perception), and adaptation practices. Complex mechanisms underlie the interplay of the three. This research confirmed that knowledge is a powerful predictor that promotes precautionary behavior. This study also confirmed that knowledge has an immediate and significant effect on people's attitudes toward risk. The results of this study provide further evidence that, in disasters with a gradual onset, people's perceptions of danger play a crucial role in causing them to alter their behavior.

Since risk perception is a latent variable that has a direct effect on precautionary behavior, it is important to understand the relation between knowledge and risk perception.

- “Dread risk factor” as mediator of knowledge and precautionary behavior. Risk perception depends on a multitude of interrelated factors. These factors can be simplified into two broad categories: fear and familiarity (Slovic, 1987), which are represented in this study by the "dread risk factor" for "fear" and an "unknown risk factor" for "familiarity." This study confirmed that risk perception mediates the relationship between knowledge and precautionary behavior. This study also confirmed that dread had a functional role in exacerbating perceived risk and was a predictor of positive behavior change.
- Forestry workers are more at risk than farmers. The moderation analysis indicated that participant groups, which reflect the characteristics of workers and their employment, moderated the association between knowledge, risk perception, and precautionary behavior. The forestry workers group is less likely to agree on precautionary behavior than the farmers' group, despite having a higher degree of knowledge. Therefore, forestry workers are more at risk than farmers.
- Develop an effective risk-communication. Heat-related information must be enhanced to boost precautionary behavior to prevent the detrimental effects of heat exposure on occupational health and potential worker earnings. The message of change, the vehicles of communication used to deliver the message, and the senders all need to be formulated with the preferences of the workers in mind. Risk communication strategies at the worker level should be constructed through more conventional means, such as face-to-face communication and demonstrations. Individual, societal, and cultural factors must all be taken into account when developing risk communication strategies (Hass et al., 2021). The message of change, the vehicles of communication used to deliver the message, and the senders all need to be formulated with the preferences of the workers. Local wisdom, such as the preference for a dark outer color, should be taken as a source of content for messages. Taking into account the characteristics of the target group in this study, it seems that "fear language" could be used to make forestry workers more aware of the risks they face. Indonesian farmers and forestry workers prefer to receive information and guidance from the government, a trusted authority and role model. Government agencies or those affiliated with the government could perhaps package and deliver the information in an informal format.

Abstract

Indonesia has witnessed climate change, typified by an increase in surface temperature. Prolonged heat exposure can cause heat-related illness (HRI) in outdoor workers. The lack of understanding of knowledge, risk perception, and preventive actions at the worker level is one of the challenges that need to be addressed in an effort to formulate health promotion and prevention program strategies to combat the threat posed by this slow-onset disaster. This confirmatory cross-sectional study was conducted in three provinces in Indonesia. A minimum of 110 questions were asked among the 425 participants (farmers and forestry workers). In addition to descriptive statistics, a Structural Equation Modeling (SEM) with the Partial Least Square (PLS) technique was used to evaluate the correlation, mediation, and moderation relationships among three latent variables: i.e., knowledge, risk perception, and precautionary behavior. This study confirmed that heat exposure caused distress among the participants. Furthermore, this study shows that knowledge is a powerful predictor that directly and indirectly promotes precautionary behavior; and, that dread, a risk perception modulator, is a predictor of positive behavior change. A risk communication strategy should be formulated based on the preferences of the workers, in which local wisdom was taken as a source of content for HRI prevention messages. Population-level studies should be carried out for a full validation of the three latent variables.
Keywords: heat exposure, heat-related illness, outdoor workers, slow-onset disaster, local wisdom

1. Introduction

1.1. Background

Global warming has caused an increase in the Earth's temperature. The United State Environmental Protection Agency (US EPA) notes that since 1901, the increase in the Earth's surface temperature in the USA has increased by 0.17˚F per decade (EPA, 2022). The Intergovernmental Panel on Climate Change (IPCC) predicts that in the tropics, average temperatures will rise by 1.6˚C in the medium-range emission scenario and 3.3˚C in the high-emission scenario (with a margin of error of around 0.5˚C in both predictions). Located in the tropical region, Indonesia has experienced climate change, which is marked by an increase in surface temperature. The Indonesian Meteorology, Climatology, and Geophysical Agency (BMKG) reports that the daily maximum temperature recorded in Indonesia in July 2022 has reached 38.8˚C for the Makassar area and 35–36.5˚C for the Java to Nusa Tenggara region. This maximum temperature increase is very extreme considering that the maximum temperature in the same region in 2012 was 32–33˚C.

In addition to bringing negative effects in the form of natural disasters, the increase in temperature will cause disruption to human health (Kjellstrom et al., 2016; Oppermann et al., 2021). The human body does have a thermoregulatory system to control heat exchange between the environment and the body in order to maintain a homeostatic core temperature of 37˚C (±0.6˚C) (Constance & Shandro, 2011). This physiological mechanism is a form of body defense from the threat of heat exposure. However, prolonged exposure to heat in humans will lead to heat-related illness (HRI) (Kjellstrom et al., 2016; Riccò et al., 2020; Oppermann et al., 2021), even occupational injuries (Varghese et al., 2018), which in turn cause extensive inherited losses, not only in the form of medical costs, but also reduced work productivity and quality of life, and even death (Schmeltz et al., 2016).

Agriculture, including forestry and its combination, agroforestry, is one of the world's most important industries and has long been known as one of the sectors hardest hit by climate change (Nelson et al., 2009). In Indonesia, there are around 33.4 million agricultural sector workers (BPS, 2022), which is equivalent to 12% of the population. Activities in this sector are dominated by outdoor activities that are associated with excessive heat exposure. The main characteristic of outdoor workers in the agricultural and forestry sectors in Indonesia is the large dependence on their work to meet financial needs. A study by Yovi et al. (2021) noted that the level of risk acceptance among laborers (especially forestry workers) tends to be high. They perceive the risk of health problems due to being exposed to the hot environment as a logical consequence that should be accepted and not an important issue to be discussed. Risk perception is a person's subjective evaluation of how they value events based on their social and cultural views. Unlike occupational safety and health (OSH) disturbances caused by falling trees or being cut by saws, health problems due to heat exposure tend to be "slow and delayed." Scholars distinguish between "sudden-onset disasters" and "slow-onset disasters" in disaster and climate studies. Terrorist attacks, earthquakes, storms, and bridge collapses are examples of sudden disasters (Orom et al., 2012; Merakl & Küçükyavuz, 2020). Meanwhile, slow-onset disasters include famine, drought, slow-moving landslides, desertification, deforestation, extreme poverty, and, in this study, climate change and its related phenomena, such as the increasing Earth's surface temperature (Nixon, 2015; Morrison, 2017; Merakl & Küçükyavuz, 2020). Slow-onset disasters have impacts that take time to manifest and are frequently discovered long after hazards have first been exposed (Orom et al., 2012). This type of calamity also has long-lasting ramifications, and those affected must continue to deal with the resulting health issues and psychosocial difficulties (Orom et al., 2012). Because the effects are typically seen over many years and decades rather than in a matter of hours or days, as is the case with most disasters, it would be challenging to motivate people to make preparations. Communities do adapt, but this happens slowly and is sometimes not perceived as change (Morrison, 2017). This ability to adapt to a slow-onset disasters causes people to be submissive and eventually accept risk as a natural occurrence, despite the fact that the losses sustained are escalating.

Since the issue of global warming has resonated, a lot of research in the agricultural sector has been directed at issues related to the effects of climate change on growth and plant productivity, pest infestation, and mitigation strategies (e.g., Malhi et al., 2021), or matters related to carbon trade schemes (e.g., Yu et al., 2022). There is very little research that takes the subject of workers in the agricultural and forestry sectors in Indonesia in relation to health problems and decreased work productivity due to exposure to heat caused by climate change. Several studies have confirmed that agricultural and outdoor forestry workers are workers who have a high potential for occupational health disorders and even occupational health injuries (Spector et al., 2014; Boonruksa et al., 2020). In fact, in relation to the Sustainable Development Goals, the international community has acknowledged that the impact of climate change on the health conditions and work productivity of workers is a major challenge (ILO, 2019). Moreover, the international community has pointed out that climate change's effects on workers' health and job productivity are a major concern that can threaten the stability of a country (Butler, 2018). Based on the health belief model (HBM; see Becker, 1974; Jones et al., 2015), changes in health behavior among outdoor workers, especially those at the laborer level, are one of the problems that need to be solved in order to come up with strategies for health promotion and prevention programs to deal with the threat of HRI.

In many studies, knowledge and attitude are the critical elements for the successful design of health promotion and prevention programs (e.g., see Anthonj et al., 2019). Hence, workers must understand what threats they face and the loss they face as a consequence in order to understand the appropriate necessary preventive measures. This risk factor can be exogenous from the work environment or individual in the form of fluid intake, physical exertion, or risk perception (NIOSH 2016). For this reason, workers must have knowledge to understand what they need (Riccò et al., 2020) in order to feel confident that the formulated strategy will make them feel safe.

The HBM concept places perceptions related to risk as one of the triggers for prudent behavior (Rosenstock, 1974), where this precautionary behavior turns the system, programs, or procedures into reality (Hass et al., 2021). From the HBM's point of view, the formulated health promotion and prevention programs are not limited to programs that are structured according to what we believe are right for workers. More than that, workers must be involved in the preparation of health promotion and prevention programs. That is, knowledge, risk perception, and prudential behavior are crucial elements that determine the success of the formulation and implementation of the formulated preventive programs (Li et al., 2016).

However, the effectiveness of preventive HRI initiatives, both through a top-down (occupational health and safety policy) and a bottom-up approach (OHS participation), is also influenced by the presence of effective communication. Additional investigation of communication factors is also important to discuss, given that risk communication has been shown to have a positive effect on knowledge and risk perception, which, in turn, triggers changes in precautionary behavior.

1.2. Purposes

As part of a plan to deal with the unavoidable effects of climate change, it is important to encourage outdoor agricultural workers to be more aware of and better able to deal with the negative effects of rising temperatures in the workplace. However, it is difficult to formulate health promotion and prevention programs to prevent the negative effects of heat exposure on workers due to a lack of information regarding complaints of health problems and work performance, as well as the basic problems experienced by workers who continue to "ignore" these risks.

Therefore, this study aimed to reveal the level of heat-related knowledge, risk perception of the negative effects of heat exposure, and precautionary behavior as a prevention strategy among Indonesian paddy farmers and forestry workers. In addition, we also examined the relationship that occurs between the three in both types of workers. By placing communication as one of the important assets in the effort to implement the adaptation strategies, this study also aimed to identify parties who tend to be accepted by the workers as the bearers of the adaptation message, the content of the message needed by the target, and the communication vehicles according to the workers' preferences. Thus, it is hoped that the form of an effective risk communication strategy can be formulated appropriately. Ultimately, we hope that the effective adaptation interventions offered in this study to address increasing occupational heat stress due to global climate change will be implemented.

Indonesia is not the only beneficiary of the study findings. The results of this study can also be used as a guide to understand the same problems that countries in other tropical developing regions face, like Malaysia, the Philippines, Vietnam, Cambodia, and Thailand. These countries have similar agricultural and forestry activities and face similar problems.

To achieve this goal, the specific objectives of this research were:

- to gain an understanding of workers and their work characteristics, such as knowledge level, risk perception, and heat-exposure precautionary behaviors.
- to look into the current relationship between heat-related knowledge, risk perception, and heat-exposure precautionary behaviors among Indonesian farmers and forestry workers.
- to get a general idea of what forms and ways of communication workers prefer in order to increase awareness of heat exposure at work and better deal with it.

1.3. Output

The output of this study is the availability of data and information needed in the preparation of adaptation and prevention strategies in dealing with climate change issues.

2. Literature Review

2.1 Climate Change, Global Warming and Its Impacts

Global warming is considered an average increase in the Earth's temperature because of both natural forces and human interference, which act like a greenhouse around the earth, trapping the heat from the sun into the Earth's atmosphere and increasing the Earth's temperature (Dincer et al., 2013). Over the last century, the measured increase in global mean surface temperature was approximately 0.5˚C (Hasselmann, 1997) and has increased by about 0.8˚C since the 19th century (Ring et al., 2012). Earth's temperature has risen by 0.14˚F (0.08˚C) per decade since 1880, but the rate of warming since 1981 is more than twice that: 0.32˚F (0.18˚C) per decade. Averaged across land and ocean, the 2021 surface temperature was 1.51˚F (0.84˚C) warmer than the twentieth-century average of 57.0˚F (13.9˚C) and 1.87˚F (1.04˚C) warmer than the pre-industrial period (1880–1900) (Lindsey & Dahlman, 2022). Undoubtedly, the warming that occurred in the 20th century has been primarily caused by anthropogenic climate change, with only a minor contribution from natural variability (Crowley, 2000; Ring et al., 2012).

As natural and human systems are pushed beyond their ability to adapt, the rise in weather and climate extremes has had some irreversible consequences (IPCC, 2022). The potential health impacts of extreme weather events include both direct effects, such as traumatic deaths, and indirect effects, such as illnesses associated with ecological or social disruption (Greenough et al., 2001). Heat waves, floods, and drought would cause an increase in disease and death (Kerr, 2007). Increased temperature and radiation are the major causes of some heat-related diseases such as skin cancer, heat stroke, heart disease, and diarrhea, which might be strongly influenced by extreme climate events (Orimoloye et al., 2019). Local climate conditions in urban settings where people live and work create most of the direct human health hazards, such as those due to the Urban Heat Island (UHI) effect (Rossati, 2017).

One extreme event related to climate change and global warming that serves as the focus of this study is excessive, even lethal, heat exposure. Mora et al. (2017) reviewed studies published from 1980 to 2014 and concluded that lethal heat events already occur frequently in the world's cities. Today, roughly one-third of the world's population is frequently exposed to climatic circumstances that exceed this lethal threshold. With only 1.5˚C of global warming, twice as many megacities (including Lagos, Nigeria, and Shanghai, China) might become heat strained, exposing more than 350 million additional people to lethal heat by 2050 (Matthews et al., 2017).

As the world's third largest emitter of greenhouse gases (Measey, 2010), Indonesia's climate extremes have changed during the last three decades (Tangang et al., 2016). The authors noticed a clear pattern of considerable warming across the region, as shown by a rising trend of temperature means and warm extremes and a declining trend of cold extremes. The yearly mean of daily maximum and daily minimum temperatures increased at the majority of the sites studied. Many cities in Indonesia, for example, Jakarta, have consistently warm temperatures near the deadly threshold year-round (Mora et al., 2017). Indonesia's most recent National Communication says that temperatures have risen significantly across the country, and a number of climate models agree that this trend is likely to continue (Kaneko & Kawanishi, 2016).

2.2 Global Warming and Occupational Health: A Focus on Outdoor Workers

When people are exposed to extreme heat, it will result in several clinical symptoms, such as heat stroke, heat exhaustion, heat syncope, and heat cramps (Kovatz & Hajat, 2008). Severe heat stroke can potentially lead to organ system damage, functional impairment, and even death (Kovatz & Hajat, 2008). Heat stress is the largest cause of weather-related deaths in the United States (Gubernot et al., 2015). Excessive heat is both an environmental and an occupational hazard. Global warming will obviously affect those who work in hot places in already hot areas. Heat exposure may be dangerous both indoors and outdoors. The following industries have had workers suffer from heat-related ailments: agriculture, construction, landscaping, oil and gas explorations, and occupations with indoor heat-generating appliances. Spector and Sheffield (2014) say that the risk of heat stress will change over time based on the industry and job. This is because weather conditions will change over space and time, but also because climate change may affect personal and job attributes.

The implications of occupational heat stress in a changing climate for employees, businesses, and global economies are significant. Occupational heat stress can have an influence on individual performance, health, and well-being as well as on workforce productivity, GDP, the sustainability of sectors of the economy, and the cohesiveness and resilience of communities (Opperman et al., 2021). Heat stress is thought to lower work productivity through the reduction of physical labor intensity as well as by deliberate actions to find ease from heat and to stay cool (Lundgren et al., 2013). Global productivity losses due to heat are predicted to increase from 1% of the total GDP in 2030 to 4% of the total GDP by 2100 (Borg et al., 2021). Productivity loss was significantly reported high in workers with direct heat exposures compared to those with indirect heat exposures (Krishnamurthy et al., 2017). Not only has heat been linked to heat-related illnesses, but it has also been linked to workplace accidents and injuries, primarily through fatigue, reduced psychomotor performance, loss of concentration, and decreased alertness (Sanchez et al., 2010; Varghese et al., 2018; Hokmabadi et al., 2020). Occupational heat stress risk is expected to be especially high in the middle-and low-income tropical and subtropical countries, where effective measures may sparse (Spector & Sheffield, 2014).

Due to rigorous activity and solar radiation, doing outdoor work in a hot area poses a high risk of heat stress. Heat exposure in outdoor workplaces is accompanied by an inescapable alteration of human physiological function and capacity for work (Ionnou et al., 2022). In hot and humid climates, every day, heat exposures continuously challenge the health of outdoor workers (Uejio et al., 2018). In India, traffic police workers were exposed to wet bulb globe temperature (WBGT) levels higher than the recommended threshold limit value, as per American Conference of Governmental Industrial Hygienists guidelines, even beyond the hottest months of the season (Raval et al., 2018). A subsequent case-crossover study in outdoor construction workers reported a 0.5% increase in the odds of traumatic injuries per 1˚C increase in maximum daily humidex (Spector et al., 2019).

Agriculture is one of the main, if not the most, important sectors in Indonesia. The Government Bureau of Statistics Indonesia (BPS) shows there were 88.43% of Indonesian informal workers in the agricultural sector, with the lowest number being in DKI Jakarta Province (52.53%) and the highest in Papua Province (98.86%) in 2021 (Badan Pusat Statistik, 2022). The agricultural sector plays an important role in economic growth (Adebayo et al., 2021). Agricultural workers have gained wide attention regarding their exposure to occupational heat. These impacts will continue to intensify over time, extending to almost all countries by the end of the 21st century: >95% of countries will face exposure to health-related heat stress (Sun et al., 2019). A multi-country observations and interventions study identified strong relationships between WBGT and the mean skin temperature of people who worked in agriculture sector. Moreover, a very strong relationship between WBGT and the metabolic rate of agriculture workers was found (Ioannou et al., 2021). A study about the workload of rice harvesters in Yogyakarta and Central Java, Indonesia showed that extreme environmental temperatures and high humidity conditions cause the harvesters' body to increase in temperature (Mulyati et al., 2020).

2.3 Heat-related Knowledge, Risk Perceptions, and Precautionary Behaviors

This study focuses on heat-related knowledge, perceptions, and precautionary behaviors among agricultural workers in Indonesia. Thus, this section will provide the theoretical background for the area.

2.3.1 Knowledge

Yates & Chandler (1991) define knowledge as mentally stored and accessible information; knowledge is a personal variable and can be tested. Knowledge can also be considered a product or a process; Akbar (2003) suggests that knowledge can be referred to as “know-what” and “know-how”. Moreover, knowledge is created through the interaction and intersection of tacit and explicit knowledge as well as through interactions among individuals or between individuals and their environments (Chou & Tsai, 2004). In many settings, knowledge levels serve as the foundation for explaining behaviors and attitudes (Akbar, 2003). In the classic economic theory, behavior and decision-making constitute rational reasoning. Thus, knowledge, in the cognitive sense, is said to be an important determinant of behavior (and/or attitude). As human behavior change occurs in three stages: knowledge acquisition, belief generation, and behavior creation, a lack of understanding is a significant barrier to acting, in particular, appropriately (Ning et al., 2020).

Riccò et al. (2020) studied knowledge of heat-related risks, which was assessed using three subscales (a series of true-false statements): (a) general knowledge; (b) knowledge of clinical features associated with heat-related illnesses, and (c) knowledge of first aid options. Examples of topics asked in the study: usual body temperature and factors that affect it, heat stroke, clinical symptoms of heat-related illness, etc. Participants of this study, safety representatives from Northern Italy, display a good understanding of the heat-health nexus. In contrast, a nationwide study of workers in Italy revealed fairly poor knowledge of heat risk among the scientific community and workers exposed to heat. Another study (Li et al., 2016), focuses on public knowledge of heat waves as part of a KAP (knowledge, attitude, and practice) study. Demographic characteristics were associated with the knowledge level of the participants; it was found that younger participants had higher knowledge levels compared to older participants. Li et al. (2016) suggested this might be related to the source of information accessed by younger participants, e.g., more modern channels (television, radio, internet), while older participants might rely on traditional channels. In addition, economic status is also suggested to affect knowledge level via education level.

2.3.2 Risk Perception

In a traditional sense, the notion of “risk” has two main elements: the probability of a hazardous event occurring and the potential magnitude of the consequences. Risk perception is a long-standing topic that has developed over the last 40 years and has expanded to many fields, from economic, disaster, environmental hazards, public health, security, and many more. Basic cognitive psychology has served as the foundation of risk perception research, particularly in the psychometric paradigm where quantitative representations of risk attitudes and perceptions were constructed (Slovic et al., 1982). Risk perception regarding a certain hazard depends on several factors (Slovic et al., 1982), including the property of the hazard itself: voluntariness, dread, knowledge, and controllability. Dread and unknown risks have been discussed in the seminal work of Slovic (1987). Slovic (1987) mapped a wide variety of risks in a two-dimensional factor space based on whether a risk is unknown and/or dreaded. Risks connected with a sensation of "dread" include those that are difficult to detect or control, result in obvious deaths, are the result of involuntary exposure, and are catastrophic in size. Dread risks set off our emotional early warning system; they raise our pulse rate and make us uncomfortable, most likely as a result of a perceived lack of control over exposure to danger and catastrophic outcomes, for example (Weber, 2006), nuclear weapons fallout, nuclear reactor accidents, or nerve gas mishaps or assaults. Meanwhile, unknown risks are those that are novel, are thought to be incompletely understood by respondents or science, and are psychologically remote, in the sense that their impacts may be delayed in time or far away (Siegrist & Árvai, 2020). Unknown risk relates to how new a danger is, how much is known about the hazard, and how readily exposure and negative outcomes may be detected. For example, chemical risks, radiation, and DNA technology may have unanticipated implications that have yet to be verified by time (Weber, 2006).

Risk perception has been a prominent subject in climate change and global warming studies. Climate change is an example of a problem where the impacts are relatively not immediate. A study of risk perception of climate change and occupational heat stress risk on 320 mining workers in Ghana revealed variations in workers' concerns and awareness of occupational heat stress and climate change risks impede the effectiveness of heat stress management. It was suggested that concerns about climate change effects and workplace heat exposure, including awareness and use of prevention and control measures, varied significantly across types of mining activities (Nunfam et al., 2019).

2.3.3 Precautionary Behavior

This section describes precautionary behaviors, or actions taken in order to prevent something detrimental to health from happening, and what factors affect such behaviors in the context of heat hazard, specifically heat waves. Khare et al. (2015) and Akompab et al. (2013) document several precautionary behaviors adopted by the public to mitigate the impact of heat, including: staying out of the sun between 11:00 and 15:00; walking in the shade; applying sunscreen; avoiding excessive physical activities; having plenty of drinks; avoiding excess alcohol; keeping an eye on the sick, elderly, and babies; going for a swim to cool down; and wearing dark-colored clothing. Several actions to mitigate the impact of heat in the workplace setting have been suggested, including wearing specialized cooling garments, (physiological) heat acclimation, improving aerobic fitness, cold water immersion, and applying ventilation (Morris, 2020).

The health belief model (HBM) is most likely the most extensively utilized paradigm for explaining precautionary behavior. The model reflects conscious judgments regarding the costs and advantages of certain activities and identifies numerous aspects that are considered to influence the adoption of precautionary behaviors (Pligt, 1998). Janz & Becker (1984) list four factors that will affect the adoption of certain precautionary behaviors: perceived susceptibility, perceived severity, perceived benefit, and perceived barriers. Moreover, sociodemographic variables, such as age, gender, and socioeconomic status, have also been known to have consistent correlations with precautionary behaviors (Sheeran & Abraham, 1996). In general, younger, richer, more educated persons who are under low stress and have a high level of social support are more likely to engage in health-promoting behaviors (Sheeran & Abraham, 1996). Path analysis was frequently used by researchers to assess the potential direct and indirect effects of socio-demographic factors on precautionary behavior (Janz & Becker, 1984).

2.4 Research Hypotheses

Based on the theoretical frameworks described above, the following are hypotheses developed for this research:

Hypothesis 1: Heat-related knowledge positively predicts precautionary behavior.

Hypothesis 2: Heat-related knowledge positively predicts risk perception.

Hypothesis 3: Risk perception positively predicts precautionary behavior.

Hyphotesis 4: Risk perception mediates the relationship between knowledge and precautionary behavior.

Hypothesis 5: External variable of sub-sector (participant group) moderates the relationships between knowledge and precautionary behavior.

3. Methodology

3.1. Work Procedure

3.1.1. Preparation

At the commencement of the project, we conducted a thorough literature review of numerous relevant theories and engaged in in-depth discussions to select the research sites, data collection techniques, and target participants. Due to the illiterate character of the interviewees, all data was collected through face-to-face interviews. The completion of the research authorization procedure was a further preparation.

3.1.2. Preliminary field survey

A field survey was conducted to review the initial description of conditions at the study site.

3.1.3. Development of interview guide/questions

A question guide was later developed based on the findings of the literature research and fieldwork. The questions were then administered to a sample of the population (30 participants). Modifications and adjustments were performed based on the test results. At this stage, there were also discussions and a lot of training to help field enumerators with many administrative and technical parts of data collection in the field, like how to interview, how to listen, and how to ask questions.

3.1.4. Data collection

Targeted participants were questioned using a structured questionnaire. The questionnaire containing all the study's question components is provided in *Appendix 1*.

3.1.5. Data analysis and verification of hypotheses

3.1.6. Reporting

3.2. Participants and Data Collection

This confirmatory cross-sectional study was conducted in Indonesia, utilizing both open-ended and closed-ended questions. The survey included 425 participants aged 15 and older who worked as rice farmers (215 participants) or forestry workers (210 participants). Both groups of outdoor workers were at the laborer level and actively engaged in physical activities. The farmer participants worked in seasonal planting, cultivation, and harvesting of rice, cassava, sweet potatoes, corn, soybeans, peanuts, watermelon, cucumbers, chili, tomatoes, mustard greens, and kale. Most of the forestry workers were hauling workers, tree fellers, and nursery workers. The majority of these occupations were classified as manual material handling tasks requiring strenuous lifting, pulling, pushing, and carrying. Cilegon and Serang (Banten Province), Jepara and Blora (Central Java Province), and Cepu (East Java Province) were surveyed between June and August 2022. These sites are in the three provinces in Indonesia that grow the most rice or have active forestry operations.

3.3. Increasing Temperature Trend at the Study Sites

The estimates of climate models indicate that Indonesia is one of the most susceptible nations to extreme heat waves (Matthews et al., 2017; Mora et al., 2017). BMKG indicates that in the RCP8.5 scenario, increasing air temperature is a significant hazard, since most inland regions in Indonesia are anticipated to suffer a rise in annual average temperature of more than 1.1˚C (based on projected increases in annual average temperature) for the period 2020–2049 compared to 1976–2005 (BMKG, 2022), as shown in *Figure 4.1*. The Government Bureau of Statistics Indonesia (BPS, 2022), utilizing observation data from the Class 1 Climatology Station in Semarang (Central Java Province), reported an increase of 34.2–35.2˚C in the maximum air temperature during the hot months (August, September, and October) for 2018–2020. In 2012, the highest temperature in Semarang and its surroundings was 32.2˚C. During the same months in 2013 and 2017, the highest temperature in Cilegon (Banten Province) climbed from 31.8–32.9˚C (BPS Kab Cilegon, 2013) to 32.7–33.4˚C (BPS Kab Cilegon, 2017).

Source: BMKG (2022).

Figure 4.1 Projected annual mean temperature change for 2020–2049 against 1976–2005 (RCP8.5 scenario) (BMKG, 2022)

3.4. Measures

Participants were asked to complete 8 groups of questionnaires containing a total of 110 questions (*Appendix 1*). Groups of employees (paddy farmers and forest workers) were used as "control variables" to eliminate any possible effects on the dependent variables.

3.4.1. Participant Demographics

The surveys analyzed demographic data (gender, age, educational attainment, marital status, and number of dependents), work experience, working hours, and working days per week. In addition, we gathered data on employee status (seasonal, permanent), work location (permanent/mobile), side jobs, payment method (daily, weekly, monthly, piece-rate, per harvest), and daily wage.

3.4.2. Climate Change Impact on Occupational Health and Climate Change Awareness

Respondents were asked to rate the perceived heat level in their job and the change in air temperature, explain its causes, inform their heat-related health issues, and inform the availability of work huts (for shelter) and closets facilities in their workplace. Heat-awareness questions were also asked to determine how heat in the workplace affected respondents' health.

3.4.3. Heat Exposure Impact on Income

Due to the variety of work techniques and payment systems, as well as the absence of clearly defined job completion targets, it was challenging to measure the decrease or increase in work productivity. Due to the workers' point of view, in which a participant's income shows how much work they did, we used the "potential-income" approach instead of the phrase "work productivity."

3.4.4. Heat Exposure Prevention Actions and Training Experience

In this questionnaire, we investigated the participants' prevention actions.

3.4.5. Heat-related Knowledge

The first latent variable, heat-related knowledge, was measured using four measurement variables: general heat-related knowledge (K1), symptoms of health problems caused by heat exposure (K2), heat exposure prevention and first aid (K3), and how heat exposure affects work performance (K4). The question items on the three subscales are based on the High Occupational Temperature Health and Productivity Suppression/HOTHAPS (Kjellstrom et al., 2009) and Riccò et al. (2020), with minor adjustments. Participants were asked to rate statements as true or false on this questionnaire. In each aspect, several questions were asked. In K1 questions, the sample included: "Normal human body temperature is >38 ˚C (reverse question)" or "sweating is the body's way of lowering internal temperature." There were 8 question items for aspect K2. For example, "The dark color of urine is a sign of dehydration." There were 14 questions in K3, with sample items such as: "When the weather is hot, reducing work hours is an appropriate strategy to avoid heat-related health problems" and "Drinking cool water is very bad for the body when working in hot environments." (Reverse the questions.) There were 8 question items in the aspect of K4, with examples including: "Health problems due to heat exposure will cause a decrease in a person's ability to work" and "It is appropriate if we continue to work even though the air temperature feels very hot, because if we rest a lot, the work target is not achieved" (reverse items). There were 38 questions from the heat-related knowledge questionnaire.

3.4.6. Risk Perception

A psychometric paradigm was utilized to assess the perceived risk of occupational health concerns resulting from severe heat exposure. Participants rated items on a 7-point Likert-type scale. First, 5 key qualitative risk perception modulators (Slovic, 1987) associated with the dread risk factor (DF; stands for the second latent variable) were asked to the participants. The 5-measurement variable for DF were: controllability of the risk (controllable-uncontrollable; DF1); gut reaction to the risk (not dread-dread; DF2); severity of consequences (low-high; DF3); fatality (non-fatal consequences-fatal consequences; DF4); risk to future generations (low risk to future generations-high risk to future generations; DF5); and voluntariness (voluntary-involuntary; DF6). The second risk element investigated was the unknown risk factor (UF) that stands for the third latent variable. The measurement variables were observability of the impact of heat exposure on their occupational health (observable-not observable; UF1), newness (old-new; UF2), familiarity/cognizance (known to science-not known to science; UF3), and immediacy of effect (immediate effect-delayed effect; UF4). Participants with lower scores perceive the risk as controllable, not dreadful, low risk, no fatal consequences, low risk to future generations, risk taken voluntarily, impact clearly observable, old risk, risk known to science, and immediate effect. In total, there were 10 questions on this risk perception questionnaire.

3.4.7. Precautionary Behavior

The 7-item scale has statements dealing with actions taken in advance to protect against occupational health disorders caused by heat exposure in the workplace. Precautionary behavior (PB) stands for the fourth latent variables. There were 16 measurement variables for PB. They were: work early in the morning (PB1), share work shifts with my coworkers (PB2), cut work hours but add work days (PB3), involve more coworkers (PB4), work intermittently (PB5), take a short break when it's hot (PB6), wear work clothes that absorb sweat easily (PB7), wear dark-color outerwear (PB8), wear whole-body layered clothes/trousers (PB9), wear a hat or similar head protection (PB10), drink a lot of water while working (PB11), avoid coffee during hot days (PB12), seek shade when it's hot (PB13), wear sunglasses to avoid glare when working on hot-sunny days (PB14), provide a first aid kit (PB15), and provide emergency protocols (PB16).

3.4.8. Communication Preferences

In the communication aspect, we explored the preferences of participants for three communication components: the change message, the communication vehicles utilized to deliver the message, and the sender.

3.5. Data Analysis

The proportion of data linked to demographics, climate change awareness, the effect of heat in the workplace on income, heat-effect prevention actions and training experience, and communication preferences in both groups of participants were determined using descriptive statistics. Based on Henseler et al (2015), a Convergent Validity Evaluation was conducted to evaluate the Reflective Measurement Model on knowledge, risk perception and precautionary behavior, with the loading factor criterion being >0.50, while the reliability of the measurement variables was evaluated using the composite reliability criterion of ≥0.7 (Dijkstra & Henseler, 2015). This outer model evaluation was conducted to eliminate invalid and unreliable measurement variables from their respective latent variables. Further, the Mann-Whitney U test statistical test was used to test the difference in knowledge, risk perception, and precautionary behavior between the groups of participants. On these variables, the Mann-Whitney U test was employed as the Saphiro Wilk test revealed a violation of normality ($p>0.05$).

3.5.1. Correlation, Mediation, and Moderation Analysis

Using the Structural Equation Model (SEM) with the Partial Least Square (PLS) technique and the SmartPLS software, the correlation, mediation, and moderation interactions between components of knowledge, risk perception, and precautionary behavior were investigated. This study used the PLS method given the small number of respondents surveyed. Only valid and reliable variables were used in the further analyses.

3.5.2. Inner Model Evaluation

Valid and reliable variables were then involved in evaluating the structural model (inner model) to predict the relationship between latent variables by looking at the inner model variance inflammation factor (VIF) value, the coefficient of determination (R^2), and the predictive relevance value (Q^2) (Hair et al., 2017; Avkiran & Ringle, 2018). The correlation (VIF) value between observed variables is not allowed to exceed 10 (Hair et al., 2018). The $Q^2>0$ value for a particular endogenous latent variable implies that the PLS path model has predictive relevance for that construct (Hair et al., 2017). In the Standardized Root Mean Square (SRMR) testing model, the model is considered to have goodness of fit if the SRMR value <0.10 (Ramayah et al., 2017). The Normed Fit Index (NFI) value takes the criteria of >0.5 (50%) (Bentler & Bonett, 1980). The hypothesis test (with the bootstrapping procedure) was carried out with the criterion of the t-statistics significance value >1.96.

3.5.3. Hypotheses Testing

In mediation evaluation, we used the Variance Accounted For (AVF) method (Preacher & Hayes, 2008) and bootstrapping in the distribution of indirect effects. According to Hair et al. (2017), the VAF value is not used as a criterion for testing mediation but is used to see the change in the effect that exists from direct to indirect relationships. Hair et al. (2017) define three types of mediation: complementary mediation, competitive mediation, and indirect-only mediation. They also defined two types of non-mediation: direct-only non-mediation and no-effect non-mediation.

4. Findings

4.1. Participants' Demographics

In the farmer group, women predominate, whereas in the forestry worker group, men do. This is most likely attributable to the physically demanding nature of forestry work. The majority of farmers have been employed longer than forest workers, but there was a weak association between age and work experience ($R^2 = 0.26$). Both groups of employees began their days between 7:00 and 8:00 a.m. and worked for approximately 7 hours. *Table 4.1* summarizes the characteristics of the participants.

Table 4.1 Characteristics of participants

Variables	Categories	Frequency	
		Paddy farmer	Forestry workers
Age		Mean = 50 (20–73); SD = 13	Mean = 44 (15–67); SD = 11
Gender	● Female	118	27
	● Male	97	183
Educational qualification	● Elementary school	168	123
	● Middle-high school	47	85
	● Degree	0	2
Marital status	● Single	94	34
	● Married	121	176
Work experience		Mean = 20 (1–60); SD = 15	Mean = 9 (1–40); SD = 8
Work hour/day		Mean = 7 (2–10); SD = 2	Mean 7 (2–12); SD = 1

Most farmers (83%) worked 7 days per week, and 17% worked 6 days per week or less. Meanwhile, 55% of forestry workers worked 6 days/week and the rest worked 7 days/week (*Figure 4.1*). 78% of the forestry workers involved in this study worked for a fixed employer. The opposite was found in the farmers' group, where 93% of the participants were seasonal workers. They only work for one employer for a certain period of time according to the agreement (usually short-term, ranging from a day to several months). When there was no work to supplement family income, up to 50% of forestry workers and 31% of farmers engaged in low-paying side occupations (housekeeper or cattle farmer). 63% of forestry workers were stationed at the same location. As for the farmers group, 54% of farmers consistently worked in the same area, while the remainder moved depending on their employer's arrangement. Farmers and forestry workers are members of the same work group, whose members are recruited exclusively through family or close friends' networks. The majority of farmer participants does not own farmland and must rely on work availability at all times.

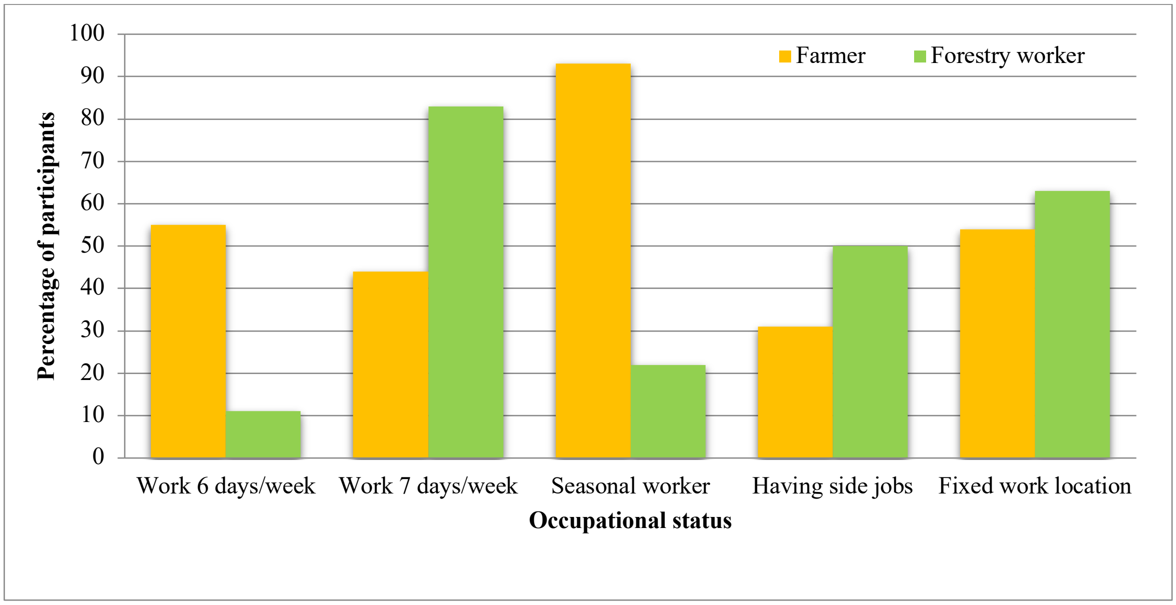


Figure 4.1 Work characteristics

Depending on the nature of the activity and the agreement between the worker and the employer, participants were paid on a daily, monthly, or irregular basis. The majority of farmers (82%) were paid daily, while the majority of forestry workers (68%) were paid on a piece-rate basis. A farmer's daily wage (net) was generally estimated to be around IDR 60,000 (USD 1 equals IDR 15,325, per October 5th, 2022), while a hauling worker could earn up to IDR 80,000 per day. Most of the people who answered the survey said that this amount was not enough to meet their family's basic needs.

We also gathered information regarding the availability of work huts and closets facilities at the worksite. 70% of forestry workers (mostly hauling workers) could reach work huts and 92% could reach closets. 75% of farmers have access to work huts. However, only 23% have access to closets. The remainder uses open space (mostly irrigation channels).

MSDs, eye pain, skin pain, hernia, asthma, gout, high blood pressure, chest pain, wounds, stomach pain, deafness, constipation, high cholesterol, and cough were the non-heat-related health complaints reported by 20% of farmers and 18% of forestry workers. 42% of farmers and 35% of forestry workers reported experiencing itchy hands and feet due to contact with muddy soil, grass, and bark.

4.2. Climate Change Impacts on Occupational Health and Climate Change Awareness

Figure 4.2 provides an overview of the effects of global warming. Most farmers (94%) and forestry workers (88%) rated the air temperature in their workplace as a 3 on a scale of 4 (4 = very hot). 66% of farmers and 73% of forestry workers shared similar feelings regarding an increase in air temperature in their workplaces over the past 5 years. 73% of farmers and 69% of forestry workers recognized that the increase in air temperature at their place of employment is a result of climate change. They explained it in simple terms: "*Many unusual natural phenomena have recently occurred, such as* *seasonal changes, increased floods, and even longer droughts. We believe that the same phenomenon is responsible for the rise in air temperature....*, "they said. Although there have been no cases of severe heat stroke, the majority of farmers (74%) and forestry workers (74%) reported that the heat is affecting their health. Most farmers and forestry workers complained of being thirsty and getting sweaty easily. Headaches and dizziness are additional symptoms of heat-related health issues experienced by the participants. Also, 75% of farmers and 88% of forestry workers said that the hot weather had made them less effective at their jobs.

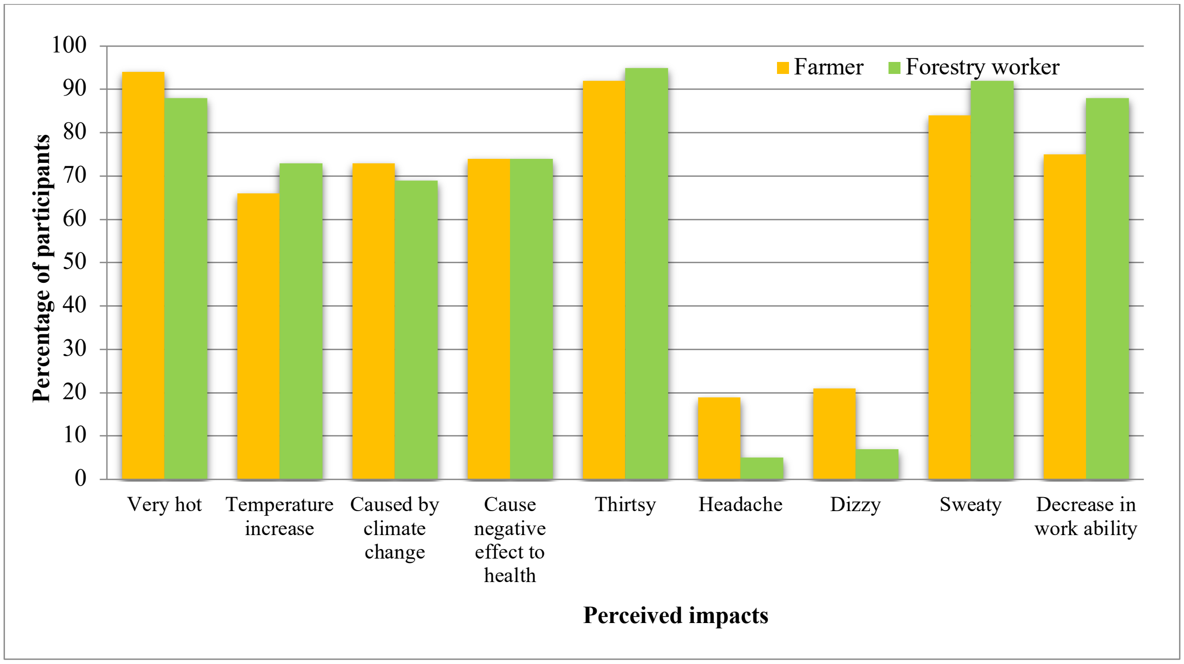


Figure 4.2 Overview of climate change impacts felt by participants

4.3. Implications of Heat Exposure in the Workplace on Income

A total of 41% of farmer participants stated that they had ever took days off due to unbearable heat. Most of the participants who had decided to take a day off reported a decrease in their income (*Figure 4.3*). In the forestry workers group, 29% of participants reported that they had been absent from work due to the heat, and almost all of this 29% mentioned their absence from work caused them to experience a significant decrease in income. It is important to note, that in addition to the decrease in income, participants also mentioned other forms of loss that should be considered before making the decision to be absent from work during hot weather. *Figure 4.4* shows that 55% of the participant forestry workers and 43% of farmers who had been absent received negative feedback from their employers. They mentioned that instead of understanding the limitations of workers, employers viewed these absences as an excuse. This condition makes both farmers and forestry workers relatively reluctant to take another day-off in the future, even if the weather is hot.

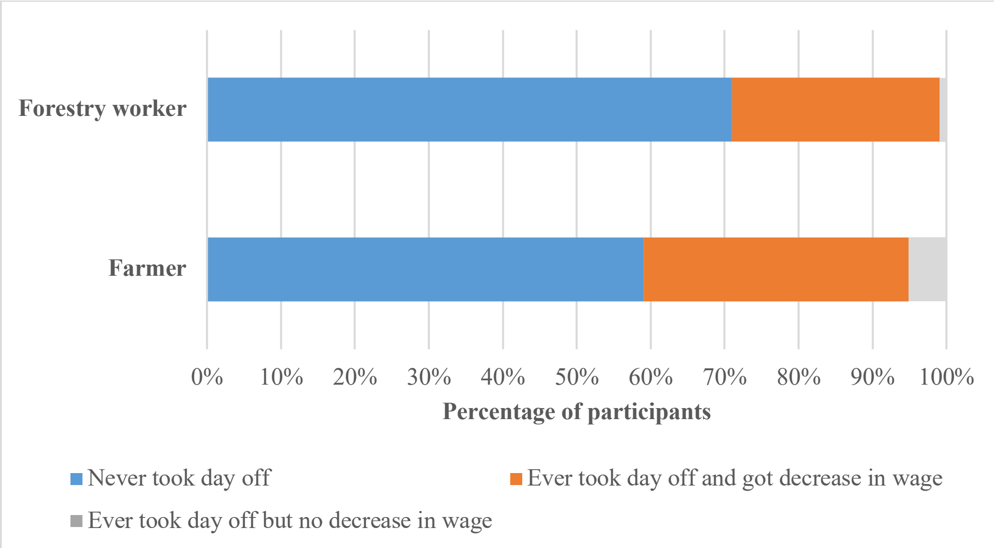


Figure 4.3 Effects of a heat-related day off on wages

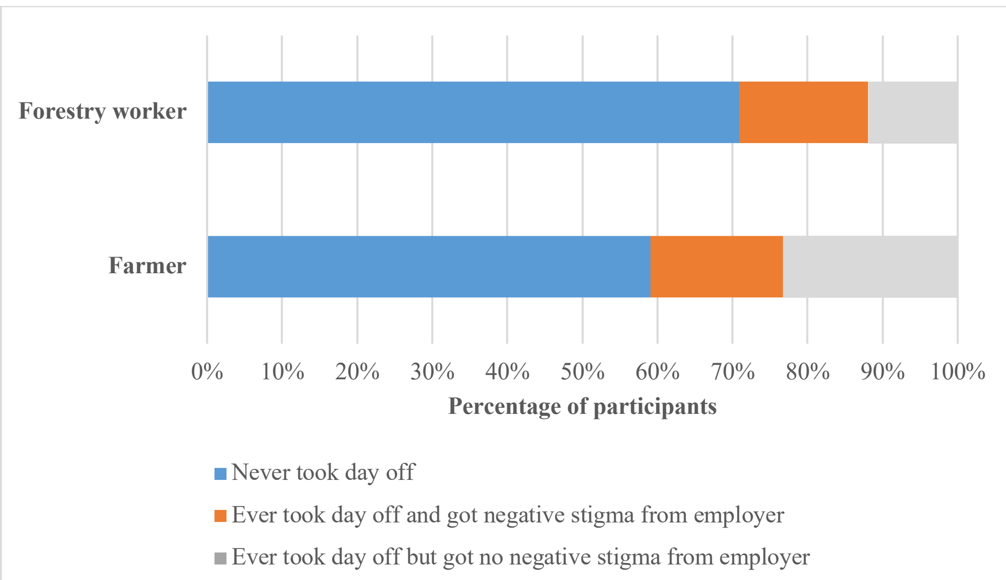
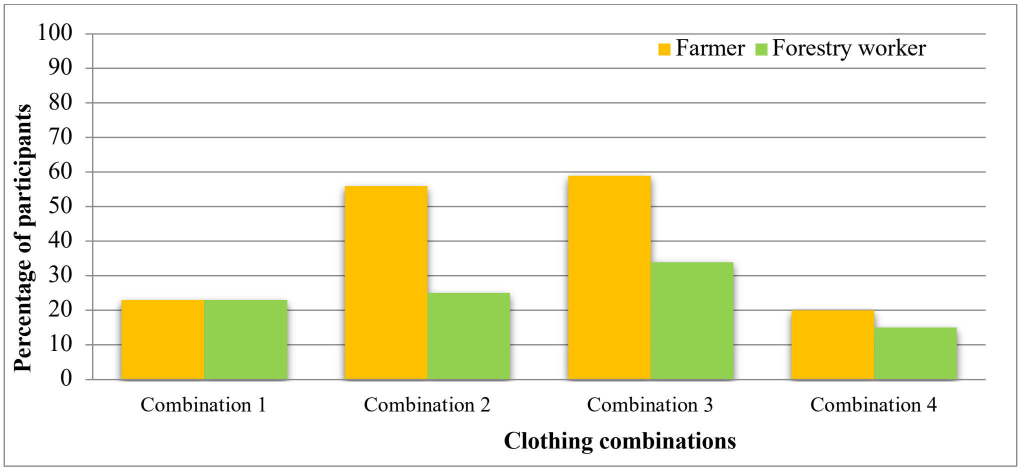


Figure 4.4 Effects of a heat-related day off on employer perception

4.4. Heat Exposure Prevention Actions and Training Experience

The majority of participants (98% of farmers and 91% of forestry workers) wore hats, including fabric and bamboo hats. In terms of clothing, 4 clothing combinations were found, namely the combination of long sleeves/trousers and dark-color outer, dark-color outer and layered clothing, layered clothing and long sleeves/trousers, and a combination of all three (*Figure 4.5*). Only 2% of farmers and 3% of forestry employees have received OSH training, in which one of the subjects is how to avoid overheating during work. Participants also reported resting, seeking shelter, drinking, and wetting their bodies with water to prevent the physiological effects of heat exposure. Regarding the provision of potable water, all respondents indicated the absence of any obstacles. 61% of farmers and 71% of forest workers mixed coffee, tea, and water while at work. 9% of participants reported that the color of their urine was dark yellow, which is a sign of dehydration.



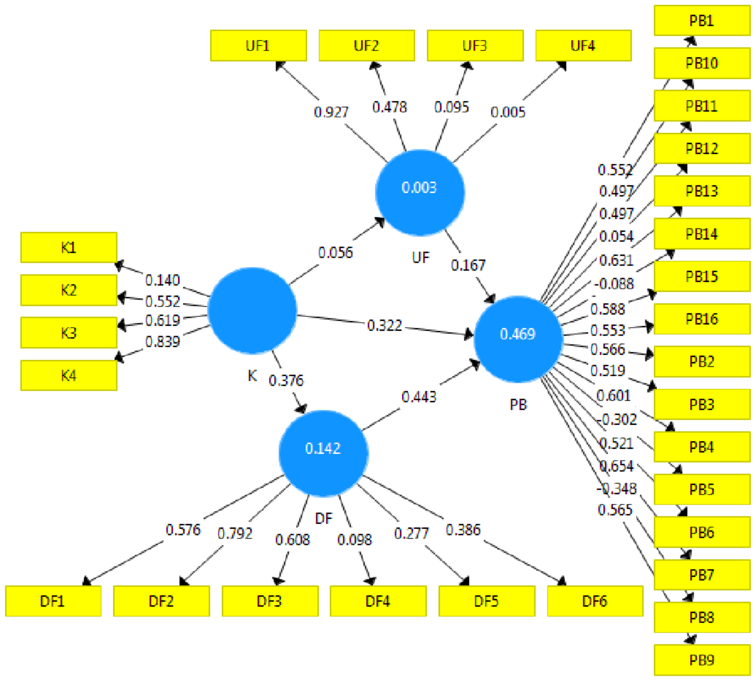
Note: Combination 1 = long sleeves/trousers-dark colored outer; Combination 2 = dark colored outer-layered; Combination 3 = layered-long sleeves/trousers; Combination 4 = long sleeves/trousers-dark colored outer-layered.

Figure 4.5 Clothing to protect againts heat exposure

4.5. Heat-related Knowledge

In terms of heat-related knowledge (K), only symptoms of health problems caused by heat exposure (K2←K; original sample O = 0.552), heat exposure prevention and first aid (K3←K; O = 0.619), and how heat exposure affects work performance (K4←K; O = 0.839) could be declared valid (loading factor >0.05; Henseler et al., 2015). The K variable was reliable, as its composite reliability was 0.715 (≥0.7; Dijkstra & Henseler, 2015). Therefore, only variables K2, K3, and K4 were analyzed further (*Figure 4.6*).

The Mann-Whitney U test revealed that farmers (Mean = 6.05, Mdn = 6.00) and forestry workers (Mean = 6.02, Mdn = 6.00, $p < 0.724$) have comparable and relatively adequate levels of awareness of signs of health concerns associated with extreme heat-exposure in the workplace (maximum score of 8). In terms of heat exposure avoidance and first aid, both groups had a high level of knowledge; however, the Mann-Whitney test revealed that forestry workers had better knowledge (Mean = 11.17, Mdn = 11) than farmers (Mean = 10.64, Mdn = 11.00), $p < 0.003$ (maximum score 14). A Mann-Whitney test revealed that forestry workers (Mean = 6.53, Mdn = 7) understood how heat exposure may affect work performance better than farmers (Mean = 6.18, Mdn = 6.00), $p < 0.018$.



Note: K = knowledge; DF = dread risk factor; UF = unknown risk factor; PB = precautionary behavior; Circle = latent variables (K, DF, UF, and PB); squares = measurement variables of each respective latent variables; single-headed arrow = the impact of one variable on another; K1 = general heat-related knowledge; K2 = symptoms of health problems caused by heat exposure; K3 = heat exposure prevention and first aid; K4 = how heat exposure affects work performance; DF1= controllability of the risk; DF2 = gut reaction to the risk; DF3 = severity of consequences; DF4 = fatality; DF5 = risk to future generations; DF6 = voluntariness; UF1 = observability of the impact of heat exposure on their occupational health; UF2 = newness; UF3 = familiarity/cognizance; UF4 = immediacy of effect; PB1 = work early in the morning; PB2 = share work shifts with my coworkers; PB3 = cut work hours but add work days; PB4 = involve more coworkers; PB5 = work intermittently; PB6 = take a short break when it's hot ; PB7 = wear work clothes that absorb sweat easily; PB8 = wear dark-color outerwear; PB9 = prefer whole-body, layered clothes/trousers; PB10 = wear a hat or similar head protection; PB11 = drink a lot of water while working; PB12 = avoid coffee during hot days; PB13 = seek shade when it's hot; PB14 = wear sunglasses to avoid glare when working on hot-sunny days; PB15 = asked my boss to provide a first aid kit; PB16 = asked my boss to provide emergency protocols.

Figure 4.6 Results of the reflective indicators' measurement model

4.6. Risk Perception

Only items of controllability (DF1←D; O = 0.576), dreadness (DF2←D; O = 0.792), severity (DF3←D; O = 0.608) (all three stand for dread risk factors) and observability (UF1←F; O = 0.927) (stands for unknown risk factor) (in the risk perception variable could be declared valid (loading factor >0.05; Henseler et al., 2015). The composite reliability of variable DF was 0.778, and 1 for UF (≥0.7; Dijkstra and Henseler, 2015), verified that DF1, DF2, and DF3 could represent DF. The composite reliability for UF was 1, indicated that UF1 could represent UF. All these measurement variables were then used for further investigation (*Figure 4.6*). A 7-scale assessment revealed that both groups of participants tended to see the deterioration of health and work performance resulting from heat exposure as alarming and leading to significant losses. This was consistent with their opinion that the rise in air temperature has bothered them (see *subsection 4.3*). They also tend to think that this risk is hard to control but can be seen (*Table 4.2*).

Table 4.2 Group descriptive for risk perception

Items for risk perception	Group	N	Mean	Median	SD	SE
	Farmer	215	3.51	3.00	1.61	0.1097

Controllability (DF1)	Forestry worker	210	3.67	3.00	1.83	0.1261
Dreadness (DF2)	Farmer	215	4.67	5.00	1.90	0.1295
	Forestry worker	210	4.84	5.00	1.87	0.1290
Severity (DF3)	Farmer	215	3.88	4.00	1.44	0.0981
	Forestry worker	210	3.95	4.00	1.40	0.0968
Observability (UF1)	Farmer	215	3.04	3.00	1.43	0.0979
	Forestry worker	210	3.05	3.00	1.53	0.1053

4.7. Precautionary Behavior

In the precautionary behavior variable, only 10 items out of 16 could be deemed valid (loading factor > 0.50; Henseler et al., 2015) (see *Table 4.3*). This variable's composite reliability was 0.842. Therefore, only these 10 items among PB were utilized for further analysis. Analysis of precautionary behavior revealed that participants in both groups agreed that prevention measures including working earlier (PB1←PB; O = 0.0552), sharing shifts with coworkers (PB2←PB; O = 0.566), reducing work hours per day (but increasing working days) (PB3←PB; O = 0.519), involving more coworkers (PB4←PB; O = 0.601), taking short breaks when hot (PB6←PB; O = 0.654), wearing double clothes (PB7←PB; O = 0.654), wearing long clothes (PB9←PB; O = 0.565), taking shelter in the shade (PB13←PB; O = 0.631), providing first aid kits (PB15←PB; O = 0.588), and providing procedures for handling emergency cases (PB16←PB; O = 0.553) are necessary (*Figure 4.6*). A more in-depth analysis using the Mann-Whitney test revealed that forestry workers are more concerned about precautionary behavior than farmers, particularly in the strategies of reducing working hours per day, involving more coworkers, providing first aid kits, and providing emergency case handling procedures (*Table 4.4*).

Table 4.3 Group descriptive for precautionary behavior

Items for precautionary behavior	Group	N	Mean	Median	SD	SE
I work early in the morning (PB1)	Farmer	215	5.89	6.00	1.42	0.0970
	Forestry worker	210	6.02	6.00	1.134	0.0783
I share work shifts with my coworkers (PB2)	Farmer	215	5.55	6.00	1.52	0.1035
	Forestry worker	210	5.87	6.00	1.141	0.0788
I cut work hours but add workdays (PB3)	Farmer	215	5.33	6.00	1.76	0.1201
	Forestry worker	210	5.70	6.00	1.499	0.1034
I involve more coworkers (PB4)	Farmer	215	6.08	6.00	1.20	0.0819
	Forestry worker	210	6.36	7.00	0.914	0.0631
I take a short break when I feel hot (PB6)	Farmer	215	6.50	7.00	1.04	0.0707
	Forestry worker	210	6.65	7.00	0.719	0.0496
I wear work clothes that absorb sweat easily (PB7)	Farmer	215	6.12	7.00	1.32	0.0898
	Forestry worker	210	6.18	7.00	1.311	0.0905
I prefer whole-body, layered clothes/trousers (PB9)	Farmer	215	6.30	7.00	1.05	0.0718
	Forestry worker	210	5.82	6.50	1.805	0.1246
I seek shade when it's hot (PB13)	Farmer	215	6.15	6.00	1.19	0.0809
	Forestry worker	210	6.37	7.00	0.792	0.0546
I asked my boss to provide a first aid kit (PB15)	Farmer	215	5.37	6.00	1.90	0.1299
	Forestry worker	210	5.91	6.00	1.398	0.0965
I asked my boss to provide emergency protocols (PB16)	Farmer	215	5.40	6.00	1.87	0.1275
	Forestry worker	210	6.11	6.00	1.310	0.0904

Table 4.4 Results of Mann-Whitney U test for precautionary behavior variables

Items	Statistic	p
I work early in the morning (PB1)	22484	0.939
I share work shifts with my coworkers (PB2)	20702	0.123
I cut work hours but add workdays (PB3)	20058	0.039
I involve more coworkers (PB4)	19655	0.012
I take a short break when I feel hot (PB6)	21570	0.320

I wear work clothes that absorb sweat easily (PB7)	21755	0.476
I prefer whole-body, layered clothes/trousers (PB9)	20752	0.113
I seek shade when it's hot (PB13)	20914	0.149
I asked my boss to provide a first aid kit (PB15)	19501	0.009
I asked my boss to provide emergency protocols (PB16)	17583	<.001

4.8. Analysis and Evaluation of the PLS-SEM Model on Aspects of Knowledge-Risk Perception-Precautionary Behavior

4.8.1 Structural Model Evaluation

The results of the test indicated that the VIF of all variables was less than 10, hence it can be stated that there was no multicollinearity between variables (*Table 4.5*). The R^2 value for the endogenous latent variable precautionary behavior is relatively moderate (40.7%), indicating that the latent variables dread risk factors and UF have a relatively moderate influence on the PB variable, although the effect of dread risk factors on unknown risk factor or vice versa is relatively low (*Table 4.6*). The $Q^2 > 0$ indicates that the model has a relevant predictive value (*Table 4.7*). The SRMR value was below 0.10 and the NFI showed that the model in this study was 56.8% (*Table 4.8*), meaning that the results show that the model in this study has goodness of fit.

Table 4.5 Collinearity assessment results

Variable	VIF	Variable	VIF
Awareness of signs of health concerns associated with extreme heat-exposure in the workplace (K2)	1.049	I cut work hours but added workdays (PB3)	1.257
K3 is heat exposure avoidance and first aid (K3)	1.087	I involve more coworkers (PB4)	1.344
Heat exposure effect on work performance (K4)	1.126	I take a short break when I feel hot (PB6)	1.441
Controllability (DF1)	1.118	I wear work clothes that absorb sweat easily (PB7)	1.777
Dreadness (DF2)	1.58	I prefer whole-body, layered clothes and trousers (PB9)	1.404
Severity (DF3)	1.44	I seek shade when it's hot (PB13)	1.61
Observability (UF1)	1	I asked my boss to provide a first aid kit (PB15)	1.871
I work early in the morning (PB1)	1.335	I asked my boss to provide emergency protocols (PB16)	1.741
I share work shifts with my coworkers (PB2)	1.357		

Note: VIF = variance inflammation factor

Table 4.6 Coefficient of determination (R^2) calculation results

Variable	R^2	R^2 Adjusted
Dread risk factors (DF)	0.07	0.068
Precautionary behavior (PB)	0.407	0.403
Unknown risk factor (UF)	0.001	-0.001

Table 4.7 Predictive relevance (Q^2) calculation results

Variable	SSO	SSE	Q^2 (1-SSE/SSO)
Dread risk factors (DF)	1,275.00	1,063.2	0.166
Heat-related knowledge (K)	1,275.00	1,228.2	0.037
Precautionary behavior (PB)	4,250.00	3,365.8	0.208
Unknown risk factor (UF)	425		1

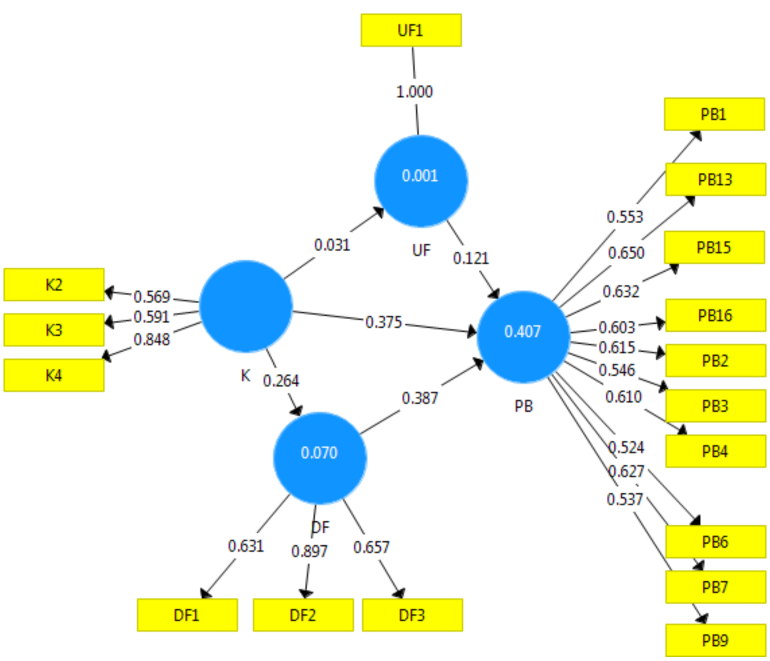
Table 4.8 Model fit analysis results

Value	Saturated Model	Estimated Model
Standardized Root Mean Square (SRMR)	0.097	0.098
Normed Fit Index (NFI)	0.568	0.561

4.8.2 Hypothesis Testing

Figure 7 presents the findings on the significance of outer loadings of the selected reflective indicator variables and the results of hypothesis testing of the direct relationship between latent variables. *Table 4.9* depicts the findings of an indirect study of the association between latent variables. The results of hypothesis testing indicated that the association between latent variables knowledge and precautionary behavior (K→PB) has a t-value = 9.561 (>t-table = 1.96) and a p-value = 0.00 (< 0.05). Thus, it was concluded that Hypothesis 1 can be accepted: heat-related knowledge significantly predicts positive preventive behavior (O = 0.375). The link between the latent variable knowledge and the latent variable dread risk factor (K→DF) was also statistically significant (Hypothesis 2) with t = 5.67 (>t-table = 1.96), p = 0.00 (0.05), and an O = 0.264. It was also revealed that both dread risk factor and unknown risk factor could predict precautionary behavior with an original sample value of 0.387% (DF→PB) and 0.121% (UF→PB), respectively.

The finding showed an association between latent variable K and latent variable PB that was mediated by latent variable DF, t = 5.28 (>t-table = 1.96) and p = 0.000 (0.05). This showed the acceptability of Hypothesis 4: DF could mediate the association between workers' knowledge of heat exposure and precautionary behavior (K→DF→PB) (O = 0.102) (*Table 4.10*).



Note: K = knowledge; DF = dread risk factor; UF = unknown risk factor; PB = precautionary behavior; Circle = latent variables (K, DF, UF, and PB); squares = measurement variables of each respective latent variables; single-headed arrow = the impact of one variable on another; K2 = symptoms of health problems caused by heat exposure; K3 = heat exposure prevention and first aid; K4 = how heat exposure affects work performance; DF1= controllability of the risk; DF2 = gut reaction to the risk; DF3 = severity of consequences; UF1 = observability of the impact of heat exposure on their occupational health; PB1 = working early in the morning; PB2 = share work shifts with my coworkers; PB3 = cut work hours but added work days; PB4 = involve more coworkers; PB6 = take a short break when its hot ; PB7 = wear work clothes that absorb sweat easily; PB9 = prefer whole-body, layered clothes and trousers; PB13 = seek shade

when it's hot; PB15 = asked my boss to provide a first aid kit; PB16 = asked my boss to provide emergency protocols.
Figure 4.7 Results of PLS Algorithm selected measurement variables

Table 4.9 Results of testing the direct relationship between latent variables

Variable	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Significance
DF→PB	0.387	0.393	0.037	10.544	0	Significant
K→DF	0.264	0.269	0.047	5.671	0	Significant
K→PB	0.375	0.378	0.039	9.561	0	Significant
K →UF	0.031	0.03	0.048	0.641	0.522	Not significant
UF→PB	0.121	0.119	0.038	3.203	0.001	Significant

Note: DF = dread risk factor; PB = precautionary behavior; K = knowledge; UF = unknown risk factor

Table 4.10 Results of testing the indirect relationship between latent variables

Variable	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	p values	Significance
K→DF→PB	0.102	0.105	0.019	5.281	0	Significant
K→UF→PB	0.004	0.004	0.006	0.603	0.547	Not significant

Note: K = knowledge; DF = dread risk factor; PB = precautionary behavior; UF = unknown risk factor

We also carried out moderation tests (*Table 4.11*). In this test, the association between the latent variable knowledge and precautionary behavior, mediated by the participant group variable (K→Participant groups→PB), gave a t = 2.19 (t-table = 1.96), and p = 0.029 (> 0.05). Thus, it was demonstrated that participant group moderated the relationship between workers' knowledge of heat exposure and precautionary behavior (Hypothesis 5; O = -0.112). Age and gender were not found to moderate the relationship between knowledge and precautionary behavior in this investigation, given that the interaction term were not significant.

Table 4.11 Results of moderation analysis of age, gender and respondent type variables

Moderation Variable	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (O/STDEV|)	p values
Age (K→PB)	-0.028	-0.031	0.051	0.544	0.587
Gender (K→PB)	-0.025	-0.014	0.051	0.495	0.621
Participant groups (K→PB)	-0.112	-0.103	0.051	2.194	0.029

4.9. Communication Preferences

97% of respondents indicated that they ever heard climate change-related information. The majority (53%) of the information came from the mass media, specifically national television. Interestingly, only 4% of respondents agreed with agricultural extension and field supervisors as information sources, despite the fact that, per technical regulations, both parties are directly related to paddy farmers and forestry workers (*Figure 4.8*). 96% of participants indicated that the information they have received thus far has been helpful, and 92% of participants indicated that they would like to get more information about climate change. From largest to smallest, the desired information content was the detrimental impact of heat on occupational health (28%), prevention strategy (26%), heat-related illness (24%), climate change-related information (12%), and emergency response (10%).

Further, 63% of respondents preferred verbal (face-to-face) information delivery, 26% preferred visual (in the form of memes, videos, or images broadcast via TV, YouTube, Facebook, or other social media), and 9% preferred written delivery (leaflets). They prefer hands-on demonstrations to learning about technical theories when it comes to topics like safety precautions and emergency procedures. The majority of attendees also prefer brief, conversational presentations. Also, participants are more likely to believe the information if it comes from government officials (like public health officials; 63%), parties connected to the participant's place of work (like farmer group members or leaders, farm owners, or employers; 16%), or parties from the participant's close community (like family members, community leaders, or neighbors; 21%).

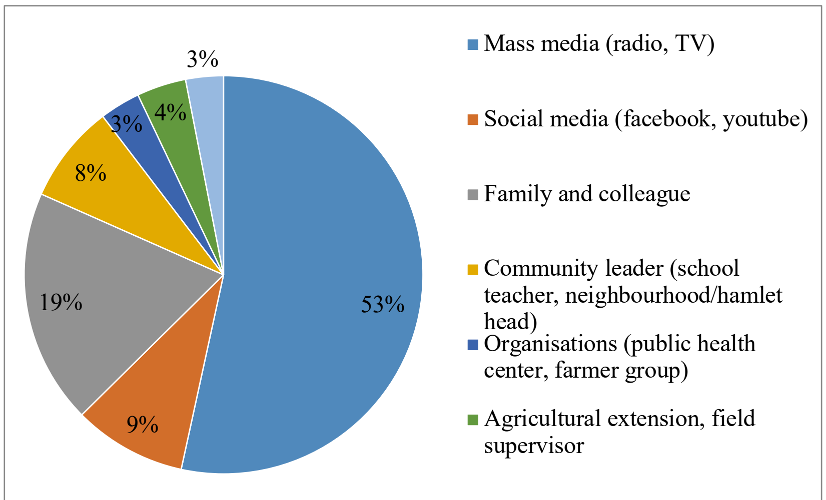


Figure 4.8 Current sources of information on climate change

5. Discussion

5.1. Climate Change Effects Awareness

In contrast to calamities like the SARS and COVID-19 pandemics, which have the nature of a rapid exposure mechanism and evident and immediate negative impacts (Vartti et al., 2009; Lee & You, 2020), the resulting repercussions of climate change are "gradual in onset" (Opperman et al., 2021).

According to the findings of this study, heat exposure caused distress among the participants. At the time of the study, participants reported feeling warmer temperatures in the workplace than in prior years, and this increased temperature was perceived as a threat to their occupational health. Participants have been observed adopting broad-brimmed hats and wearing long, layered, or dark-color outerwear in accordance with their local knowledge. Evidence such as the Bedouins' clothing, which apparently helps them regulate their body temperature through the skin's surface thermal balance mechanism in hot deserts (Shkolnik et al., 1980), supports the notion that adaptation strategy initiatives can and should integrate local knowledge. Obviously, preventative clothing measures must also consider the textile material they wear (Holmér, 2006). Even while work huts are required for shelter and closets are required for urination, not all participants have access to these vital facilities. Workers, particularly female workers, were forced to endure urinating in the absence of closets. Urination is an essential biological requirement for human health. Urinary retention can eventually weaken the muscles of the bladder and lead to urinary tract infections caused by bacterial buildup. The participants were also cautious about taking days off during hot days since it would impair their employers' or coworkers' trust in them and result in a significant wage decrease (as a result of the payment system). This study shows that workers are not in a good position to negotiate, even when it comes to their basic needs.

5.2. Latent Variables that Influence Precautionary Behavior

This research confirmed that knowledge is a powerful predictor that promotes precautionary behavior. This result is consistent with prior findings (Mishra & Suar, 2007; Li et al., 2016; El-Shafei et al., 2018). The results of the study also demonstrated that knowledge has an immediate and significant effect on people's attitudes toward risk, which is consistent with earlier studies' conclusions (Iorfa et al., 2020; Riccò et al., 2020; Hass et al., 2021; Beckmann & Hiete, 2022). The results of this study provide further evidence that, in disasters with a gradual onset, people's perceptions of hazards play a crucial role in causing them to alter their behavior, versus those with more information are more aware of the hazards. This study also confirmed that risk perception is a latent variable that has a direct effect on precautionary behavior, which is in line with the findings of Liu et al. (2013) and Li et al. (2016). This study shows that 3 of the most important factors in reducing the health impact of heat exposure are knowledge, attitude toward risks (risk perception), and adaptation practices, in which, complex mechanisms underlie the interplay of the three. In the case of farmers and forest workers in Indonesia, we believe that efforts to improve their precautionary behavior must begin with a focus on increasing their knowledge. We stress this point because knowledge has a direct effect on both taking precautions and how people see risks, and risk perception has a direct, positive relationship with taking precautions.

5.3. Risk Perception (Dread Risk Factor) as Mediator of Knowledge and Preventative Behavior

This study provided evidence to support the hypothesis that an individual's perception of risk mediates the connection between knowledge and preventative behavior. People will become more concerned about the risk as their knowledge grows, motivating them to adopt a preventative measure. These results are consistent with those found by Mishra and Suar (2007).

Risk perception depends on a multitude of interrelated factors, but these factors can be simplified into two broad categories: fear and familiarity (Slovic, 1987), which are represented by the dread risk factor for "fear" and an unknown risk factor for "familiarity." Further, Slovic (1987) explained that "dread" serves as a risk perception modulator that more accurately reflects how a risk is assessed; the higher the "dread" score, the greater the perceived risk. This study discovered that "dread" was the only risk perception modulator that significantly, albeit weakly ($O = 0.102$, $p = 0.000$), mediated knowledge with the adoption of protective behaviors. By comparing the dread risk factors (controllability, dreadness, and severity) to the unknown risk factor (observability), this study confirmed that dread had a functional role in exacerbating perceived risk and was a predictor of positive behavior change, which is in line with Harper (2020) and Ning et al. (2020). In light of this, the fact that the unknown risk component, as yet another risk perception modulator, cannot mediate the relationship between knowledge and precautionary behavior, does not considerably contradict the conclusion that risk perception is capable of mediating this relationship.

5.4. Participants Group (Work and Worker Characteristics) as Moderator of the Knowledge and Precautionary Behavior Relationship

The moderation analysis of this study indicated that neither age nor gender moderated the association between knowledge, risk perception, and precautionary behavior. Iorfa's research (Iorfa et al., 2020) corroborated this finding. Previous studies have indeed shown that women have a higher risk awareness than males (Binazzi et al., 2019; Yovi et al., 2021), as Slovic and Peters (2006) and Skagerlund et al. (2020) suggest that affect may trigger this heightened awareness in women. We presume that the unbalanced gender ratio between male and female participants (1:2) in this study may contribute to possible bias in the findings.

The association between knowledge and preventive behavior was significantly moderated in a negative direction by the third variable, participant groups, which reflected worker characteristics and employment. Despite having a greater level of knowledge, the group of forest workers is less likely than the group of farmers to agree on precautionary behavior (Table 4.4). We hypothesized that this result was attributable to the fact that forestry work, particularly manual labor, is associated with significant occupational health and even safety problems (Poulianiti et al., 2019; Yovi & Yamada, 2019). Heat-exposure is a form of disturbance for forestry workers, but because they are accustomed to being in direct contact with various sources of hazards (which cause more immediate effects), have experienced incidents with greater fear and severity effects (Yovi & Prajawati, 2015; Yovi et al., 2016), and have a high reliance on this work, the heat-exposure disturbance is viewed as minor. This high rate of acceptance may also be triggered by affect, a cognitive mechanism of risk-benefit distribution assessment (Alhakami & Slovic, 1994; Slovic & Peters, 2006; Skagerlund et al., 2020).

Despite having to cope with a number of potential hazards, workers in this position have little choice but to finish their tasks in order to earn the wages they so sorely need. This finding indirectly confirmed the findings of Harper et al. (2020) and Ning et al. (2020) that fear serves a functional function and is a predictor of positive behavior change. Therefore, we suggest that forestry workers are more at risk than farmers, and that techniques to promote cautious behavior towards heat-exposure will be more complex and intense for forestry workers.

5.5. Implementation and Recommendations

Workplace heat exposure is a slow-onset disaster, so acclimatization is possible (Schweiker et al., 2018). This slow-onset disaster could affect health, well-being, and productivity, as well as social and economic factors on a larger scale (Schmeltz et al., 2016; Krishnamurthy et al., 2017; Uejio et al., 2018; Oppermann et al., 2021; Ionnou et al., 2022).

In the case of Indonesian farmers and forest workers, knowledge is a critical element that must be addressed. Workers will be able to properly identify the hazards that emerge as a result of severe heat exposure in their workplace if they have a thorough understanding of the threats. This improved knowledge and risk perception will raise workers' awareness to engage in preventative action. The moderation effect of participant groups that was revealed in this study strengthens the indication that negative experiences could be considered as a source of "knowledge" in relation to precautionary behavior. The "severity of the personal consequences experienced in the past" may be more influential than the "experiences" themselves in shaping an individual's propensity to take preventative measures (Wachinger et al., 2012). This is connected to the research of Seimetz et al. (2016), which noted that the perception of vulnerability to a specific risk, a positive belief (the distribution of benefits is greater than the risk), confidence in one's own abilities to perform the behavior, and a commitment to performing the precautionary behavior all play a role in determining whether or not a person makes a change in their behavior.

Further, we agree with Slovic's concept that "fear" best describes how one feels when they realize how exposed they are to a particular risk (Slovic, 1987). As a form of intervention that is expected to correct risk perception and have the effect of increasing precautionary behavior, stressing the "fear" seems to have potential in groups of workers with a high sense of risk acceptance, such as the group of forestry workers, especially at laborer level, in Indonesia, who view working in a high-risk environment as a "specialty to be proud of" (Yovi et al., 2021). It appears that the use of "fear language" can be considered for the purpose of increasing forest workers' risk perception, taking into account the characteristics of the target audience in this study. But fear-based language is not a "one-size-fits-all" solution, so it should be used with care (Whitmer & Sims, 2021).

Heat-related information must be enhanced to boost precautionary behavior in an effort to prevent the detrimental effects of heat exposure on occupational health and potential worker wellbeing. Beckmann and Hiete (2021) imply that communication increases the sense of risk. This information must be conveyed to the target using an approach tailored to the target's characteristics and preferences. When developing risk communication strategies, individual, societal, and cultural factors must all be considered (Hass et al., 2021). The message of change should be delivered more frequently. Furthermore, the vehicles of communication used to deliver the message and the senders must all be formulated with the target's preferences in mind (Lefevre et al., 2015). Despite the survey's finding that national television is the most popular source of information, additional information must be disseminated through various vehicles in order to raise awareness and implement preventative measures. In accordance with Bonafede's study (2022), we propose that risk communication strategies at the laborer level for farmers and forestry workers should be developed using more conventional means, such as face-to-face communication and demonstrations. Moreover, government agencies or those affiliated with the government should package and distribute the information in an informal format. In accordance with the local culture in Indonesia (Yovi et al., 2016), farmers and forest workers must receive information and guidance from the government, as they view it as a trusted authority and role model. The findings are consistent with those of Visschers and Siegrist (2008) and Renn and Rohrmann (2000), who also found that trusted authorities are often looked to as the ultimate arbiters of risk. Local knowledge, such as the preference for a dark outer color, can be considered as a source of information regarding the message content.

To attain one's objectives, one must alter one's behavior, which Duckworth and Gross (2020) compared it to climbing stairs. Consistent effort is required, and the walker should not stop or turn around while on the stairway; otherwise, he will not reach his destination. This implies that the expected precautionary behavior must be consistently maintained at all times, and the program must be action-oriented and not merely administrative, as was underlined by Yovi and Nurrochmat (2018).

6. Conclusion

Outdoor workers, who in this study were represented by farmers and forestry workers, were found to have lower bargaining power, making them less flexible in advocating their work conditions. As a result, even though they were suffering from the effects of climate change (prolonged heat exposure), they were unable to do much to alleviate the situation. Because of this, threats, constraints, and the capacity of outdoor workers to take preventive actions must be thoroughly recognized to formulate effective health promotion and prevention program strategies.

This study indicated that having good knowledge about heat exposure will probably lead to more cautious behavior. If the target knows that being exposed to heat could be dangerous, they are more likely to take steps to protect themselves. This study also verified that knowledge correlates with risk perception, which in turn, risk perception will positively affect precautionary behavior. Concerning risk perception, there was evidence that fear, in workers having high risk tolerance, such as the forestry workers in this study, is a modulator that may have a considerable positive effect on how well an individual perceives hazard. Therefore, while highlighting preferences in the message of change may be effective, it appears that stressing "fear language" may also be effective in risk communication. However, additional research and investigation into this topic will be required.

7. Limitation

Farmers and foresters involved in the production of various agricultural products participated in this study. Work availability and total work volume in this industry depend heavily on external factors, such as the presence or absence of buyers, the number of workers in a work group, rainfall, soil conditions, diseases and pests, the quality of planted seeds, and even the size of the wood or log. When calculating work productivity, it was difficult to estimate the ratio between output (work volume; in ha or m^2 or tons or plots) and input (work time; in workdays or hours) per individual due to the diversity of work systems and wage systems. In fact, time and motion study method will provide empirical data that accurately describes the decline in work productivity, unaffected by the skewed effects of these external factors. Due to time and resource constraints, we used a subjective approach in this study by substituting work performance for work productivity. Moreover, only nursery work is performed by women in the forestry industry; men are employed in physically demanding occupations such as logging and manual hauling. Due to the limited number of nurseries in the research area, the ratio of female to male forest workers was constrained, which we believe prevents the gender variable from having a moderating effect, as suggested by numerous previous studies. This study was also restricted by the number of participants, the time constraints, and the language barriers in the local area. Some of the latent variables that were tested for validity and reliability in this study probably failed for all three of these reasons.

Institutional Review Board Statement

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Human Research Ethics Committee of the Bogor Agricultural University (Protocol N. 03/IT3.KEPMSM-IPB/SK/2022), 23 June 2022.

Author Contributions

Conceptualization, E.Y.Y. (Efi Yuliati Yovi); Technical preparation: E.Y.Y, A.N. (Anindrya Nastiti); Data collection E.Y.Y.; Data analysis, E.Y.Y, B.K. (Budi Kuncahyo); Writing-original draft preparation, E.Y.Y, A.N.; Writing, review and editing, all authors. All authors have read and agreed to the published version of the manuscript.

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Appendix 1: Interview Guidance

Preparation:

1. Select interviewees.
2. Introduce yourself and describe the goal of the study and methods of data collecting according to the Explanation Before Informed Consent.
3. Obtain informed consent from the respondent by having him or her sign an Informed Consent form.
4. Record the interview session and add the respondent code GROUP-NO-LOCUS-GENDER on the recording.
5. Proceed with the interview.

Interview record identity
1. Date of interview 2. Name of interviewer 3. Interviewee's code

General information

Part 1. Demographics information
1. Name.................................... Gender (M/F) 2. Age...years 3. Ethnicity... Marital status (single/married) 4. Highest educational attainment, choose: none; elementary school/equivalent graduate; middle school/equivalent graduate; high school/equivalent graduate; university 5. Current illness 6. Head of household (yes/no). Number of dependents .... persons

Part 2. Work description
1. Job description.. 2. Work experience.........................year 3. Is this work is your main occupation? 4. Average number of working hours .... hours/day .... days/week 5. Start work at .... finish at .... 6. Work system: seasonal/permanent 7. Does your work location move around? (yes/no) 8. Your wage is paid daily, piece rate earning, weekly, monthly, uncertain, others....... 9. Do you have a side job? (yes/no) If "Yes", please describe............................ 10. Is the wage from this side job higher than your job as a farmer/forestry worker? (yes/no) 11. Describe the availability of closet facilities in the workplace.

Climate change impact on occupational health and climate change awareness

Part 1. Heat exposure during work

1. Does the hot air in your workplace affect your health? (yes/no)
2. How does the heat affect your health? Refer Table 1, to direct the answers
3.

Table 1. How does the heat distress your body?

No.	Complains	No.	Complains
1	Thirst	11	Swollen tongue
2	Headache	12	Little urine flow and dark yellow or concentrated color
3	Muscle cramps	13	High fever of more than 39°C
4	Dizziness	14	Fainting
5	Fatigue	15	Confusion
6	Nausea	16	Lethargy
7	Pale skin	17	Seizures
8	Profuse sweating	18	Difficulty breathing
9	Inability to sweat	19	Chest or abdominal pain
10	Dry mouth	20	Fast heartbeat or palpitations

Notes: 1–5: mild overheating; 6–12: moderate overheating; 13–20: severe overheating

Part 2. Climate changing awareness

1. Do you feel that recently (in the past year) the air temperature in your workplace has become hotter? (Yes/No)
2. What phenomena in your workplace do you think are indicative of recent climate change? (e.g., erratic dry months, more heat than ever before)
3. Has the climate change reduced your performance? (Yes/No), Please describe how it affected your performance

Effects of heat exposure to work performance (income)

1. Have you ever taken days off due to heat? (Yes/No).
2. If the answer to point 1 is "Yes", do you think this affects your income? (Yes/No).
3. If the answer to point 2 is "Yes", how much do you feel disadvantaged by this reduction in income? (Select one number representing 1 to 7)

Not at all disadvantages					Very disadvantages	
1	2	3	4	5	6	7

4. If the answer to point 1 is "Yes", has this caused your farm owner/boss to have a negative view of you? (Yes/No)
5. If the answer to point 4 is "Yes", how much do you feel disadvantaged as a result of the negative view of your farm owner/landlord/boss? (Select one number that represents 1 to 7)

Not at all disadvantages					Very disadvantages	
1	2	3	4	5	6	7

Negative Heat-Effect Prevention Actions and Training Experience

Part 1. Heat exposure during work

1. What you wear to work (mention the material, color, size, layers) ....
2. Do you have a particular reason for your choice of work clothes? (yes/no) What is the reason? ....
3. Do you continue working even on hot days? (yes/no), if "Yes" how long do you continue working .... hours.
4. If you're hot, what do you do ....
5. If drinking a lot of water is among your answers, how much water do you drink while working...........
6. What kind of liquid that you drink during work? ....
7. Is there plenty of drinking water available when you are working? (yes/no), if not explain why....
8. The color of your urine when you urinate during work: (light yellow/dark yellow) Use the hydration cart.

Part 2. Heat-protection training experience

1. Have you ever participated in training related to OHS? (Yes/No)
2. If "yes", what are the topics related to heat exposure obtained from the training..........

Heat-related knowledge

Part 1. General knowledge of human body mechanisms in relation to heat exposure (adopted from Riccò et al. 2020)	Correct Answer
1. The normal temperature of the human body is higher than 38˚ C.	Wrong
2. The heart will beat faster when working under heat exposure	Right
3. Working under prolonged heat exposure has the potential to cause health problems.	Right
4. Men are more resilient to scorching heat exposure than women.	Wrong
5. Health problems due to activities under the scorching heat only occur in children and the elderly.	Wrong
6. Sweating while working in the heat is good for lowering body temperature.	Right
7. The head is the only part of the body that is sensitive to heat exposure.	Wrong
8. Health problems due to exposure to scorching heat will not lead to death.	Wrong

Part 2. Symptoms (adopted from Riccò et al. 2020)	
When you work under heat exposure:	
1. Excessive thirst is not a symptom of mild overheating.	Wrong
2. Headache is a symptom of mild overheating.	Right
3. Muscle cramps are a symptom of mild overheating.	Right
4. Dizziness is a symptom of mild overheating.	Right
5. High fever is a symptom of severe overheating.	Right
6. Fainting is not a symptom of severe overheating.	Wrong

7. Fast heartbeat is a symptom of severe overheating.	Right
8. The dark color of urine is a sign of dehydration.	Right

Part 3. Prevention and First aid (adopted from Riccò et al. 2020)	
When you feel work under sun exposure or experience overheated:	
1. Drinking coffee instead of water will effectively lower body temperature.	Wrong
2. Drinking hot water will significantly lower your body temperature.	Wrong
3. Pouring cold water over the body is an effective way to reduce body temperature.	Right
4. Wearing loose clothing is not good for helping the body to lower body temperature.	Wrong
5. Cotton is great for inner workwear as it absorbs sweat well.	Right
6. Wearing outer made of polyester will prevent the sun's rays from reaching the skin surface underneath your clothes.	Right
7. Wearing loose outerwear made of dark-colored polyester material combined with a light-colored cotton shirt as an inner could protect the body from excessive heating.	Right
8. When working in hot environments, drinking cold (cool) water is harmful to the body.	Wrong
9. Immediate shelter can alleviate the symptoms of health problems caused by mild exposure to heat.	Right
10. When a patient faints due to heat, it is advised to cover them with a thick blanket or cloth.	Wrong
11. When the temperature is high, it is prudent to reduce working hours in order to prevent health issues caused by overheating.	Right
12. Working early in the morning is an effective method for avoiding heat-related health issues.	Right
13. Mild heat exposure can make health problems worse but getting shelter right away can help.	Right
14. Wearing a wide-brimmed hat effectively reduces the negative effects of workplace heat.	Right

Part 4. Work performance	
1. Increasingly intense temperatures and exposure to the sun cause a decrease in a person's ability to complete work.	Right
2. Health problems due to heat exposure will cause a decrease in one's ability to work.	Right
3. Work productivity will decrease if the time required to complete the work becomes longer.	Right
4. Work quality may drop when workers work under excessive heat exposure.	Right
5. Decreased work performance can lead to a decrease in income.	Right
6. Decreased work performance does not cause a loss to the worker.	Wrong
7. Decreased labor performance does not cause losses to the employer/landowner.	Wrong
8. It is right to continue working quickly even when the temperature is very hot, because if we rest a lot, we will not achieve our work targets.	Wrong

Risk perception: dread risk factor		
Controllability	How well can you control the negative health effects of heat exposure at work?	
	Highly capable of control ⮟	Uncontrollable at all

	1	2	3	4	5	6	7
Dread	How dreadful are the health risks associated with heat exposure?						
	Not dreadful at all		⮟				Extremely dreadful
	1	2	3	4	5	6	7
Severity	How severe are the health issues that result from exposure to heat?						
	Not severe at all		⮟				Very severe
	1	2	3	4	5	6	7
Fatality of consequences	How likely is it that heat exposure will cause death?						
	Impossible		⮟				Very possible
	1	2	3	4	5	6	7
Risk increases in the future	How likely is an increase in the risk of heat-related disorders in the future?						
	No potential to increase		⮟				Highly potential to increase
	1	2	3	4	5	6	7
Voluntarily	How voluntarily are you accepting the heat-related risks?						
	Voluntarily		⮟				Involuntarily
	1	2	3	4	5	6	7

Risk perception: unknown risk factor

Observability	How clear are the adverse effects of exposure to heat?						
	Very obvious		⮟				Very not obvious
	1	2	3	4	5	6	7
Newness	How long have you been aware that heat exposure at work might cause health problems and even death?						
	Long recognized		⮟				Recent knowledge
	1	2	3	4	5	6	7
Familiarity	How well understood are the adverse health effects of heat exposure?						
	Very familiar		⮟				Very unknown
	1	2	3	4	5	6	7
Immediacy	How quickly do adverse health effects result from heat exposure in the workplace?						
	Immediately		⮟				Delayed
	1	2	3	4	5	6	7

Precautionary behavior

How do you feel about the following statements?

Items	1 = Absolutely not necessary			⮟		7 = Absolutely necessary	
1. I work early in the morning	1	2	3	4	5	6	7
2. I share work shifts with my coworkers	1	2	3	4	5	6	7
3. I cut work hours but add workdays	1	2	3	4	5	6	7
4. I involve more coworkers	1	2	3	4	5	6	7
5. I work intermittently.	1	2	3	4	5	6	7
6. I take a short break when I feel hot	1	2	3	4	5	6	7
7. I wear work clothes that absorb sweat easily	1	2	3	4	5	6	7
8. I wear dark-color outerwear.	1	2	3	4	5	6	7
9. I prefer whole-body, layered clothes/trousers	1	2	3	4	5	6	7
10. I wear a hat or similar head protection	1	2	3	4	5	6	7
11. I drink a lot of water while working.	1	2	3	4	5	6	7
12. When it's hot day, I avoid coffee.	1	2	3	4	5	6	7
13. I seek shade when it's hot	1	2	3	4	5	6	7
14. When working on hot-sunny days, I wear sunglasses to avoid glare.	1	2	3	4	5	6	7
15. I asked my boss to provide a first aid kit	1	2	3	4	5	6	7
16. I asked my boss to provide emergency protocols	1	2	3	4	5	6	7
17. I seek heat-exposure related OSH information in numerous media.	1	2	3	4	5	6	7
18. If I'm overheated at work, I visit a health clinic.	1	2	3	4	5	6	7

Communication strategies

Part 1. Current sources of information

1. Have you ever received information concerning climate change, such as heat exposure? (Yes/No).
   If "Yes," where did you obtain the information?
   Radio/TV/newspaper/social media/family members/ coworkers/local community/organization/agricultural extension workers/other ....

2. Do you find the information useful?

Not very helpful		⮟				Very helpful
1	2	3	4	5	6	7

3. Do you need more relevant information?

Really do not need		⮟				Urgently need
1	2	3	4	5	6	7

Part 2. Preferred contents

If a program existed to provide information on heat exposure, what information would you prefer to receive? (Choose from the options below; if more than one answer is given, sort by necessity.)

- Data pertaining to climate change.
- Information about the adverse health effects of exposure to heat.
- Information regarding the symptoms of heat-related illnesses.
- Information about how to reduce or avoid the adverse effects of heat exposure on health.
- Information regarding emergency response to heat-related illnesses.
- Other......................................

Part 3. Preferred communications vehicles.

1. What is your preferred method of contact? (Verbal/Written/Visual)
2. Do you enjoy hands-on experience with topics like preventative and emergency response techniques? (Yes/No)
3. How should the information be conveyed? (Formal/Informal)
4. Which length of message do you prefer? (Short/Long)