

The background of the cover features silhouettes of four diverse individuals: a woman with curly hair on the left, a man in the center, a woman with a ponytail on the right, and a man in the foreground on the right. They are rendered in shades of blue and teal against a dark blue background.

Negative Psychosocial Effects of Heat Waves, Flooding, Forest Fires, and Storms on Québec Workers

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LIST OF ABBREVIATIONS AND ACRONYMS

CC	Climate change
CHUM	Centre hospitalier de l'Université de Montréal
CIUSSS	Centre intégré universitaire de santé et de services sociaux
EWE	Extreme weather events
PTSD	Post-traumatic stress disorder
INSPQ	Institut national de santé publique du Québec
MSSS	Ministère de la Santé et des Services sociaux

KEY MESSAGES

- In the implementation of Québec's 2013-2020 Climate Change Action Plan, the ministère de la Santé et des Services sociaux mandated the Institut national de santé publique du Québec with conducting an exploratory study on the psychosocial effects experienced by workers as the result of four extreme weather events, the frequency of which will be exacerbated by climate change: heat waves, flooding, storms, and forest fires.
- It aims to briefly examine the literature and knowledge of various key actors in order to propose more significant next steps for research projects that respond to Québec's workplace and public health needs and issues.
- This study has shown:
 - The extreme weather events studied can have psychosocial effects on workers, but the knowledge of these effects varies greatly by event.
 - The psychosocial effects on workers have been the most thoroughly documented in the scientific literature for storms, less well documented for floods and forest fires, and little documented for heat waves.
 - Frontline workers (such as municipal employees, police officers, firefighters, health professionals who provide services to emergency victims, public works employees, etc.) and farmers are among the most studied groups of workers.
 - Negative psychological effects like burnout, fatigue, psychological distress, anxiety, anger, and sadness were reported more often in the literature than social impacts.
 - There are organizational risk factors (e.g., overwork; lack of training, material resources or available staff) and personal risk factors (e.g., being a disaster victim oneself, lack of contact with family members) common to several events and types of workers that can exacerbate the psychosocial effects workers experience. There are also protective factors (e.g., appreciation or gratitude, individual resilience, social support, and collective efficacy).
 - It is important to consult key actors to improve the knowledge from the scientific literature. Consultations with key actors conducted as part of this study made it possible to identify new vulnerable workers, learn more about the characteristics of some extreme weather events, and learn that the psychosocial effects following these events can be positive.
 - Acquiring knowledge on the psychosocial effects experienced by workers following a flood responds to the workplace and public health needs and issues in Québec.

SUMMARY

In 2017, the Institut national de santé publique du Québec was mandated by the ministère de la Santé et des Services sociaux du Québec (MSSS) to conduct research on the psychosocial vulnerability of workers in relation to climate change. This mandate was part of the implementation of Action 26.3 of the Government of Québec's 2013-2020 Climate Change Action Plan, which focuses specifically on reducing psychosocial effects related to extreme weather events.

This report presents an exploratory study conducted in response to the mandate given by the MSSS. The aim of this exploratory study is to briefly examine the literature and knowledge of various key actors in order to propose more significant next steps for research projects that respond to Québec's workplace and public health needs and issues. The study focused more specifically on the psychosocial effects caused by four extreme weather events that will be exacerbated by climate change in Québec: heat waves, flooding, forest fires, and certain types of storms.

The specific objectives of this study were as follows: 1) to summarize the knowledge on the psychosocial effects experienced by workers following heat waves, floods, storms, and forest fires; 2) to validate the knowledge reviewed, identify gaps, and determine the priority issues for workplaces and public health, as well as avenues for research and intervention; and 3) to establish an order of priority for avenues for research and intervention.

To achieve the first objective, a brief review was conducted on the psychosocial effects experienced by workers following heat waves, flooding, storms, and forest fires. The literature search was carried out using MEDLINE, Embase, Psych. and Behav. Sc. Coll., APA PsychInfo, SocINDEX, and Environment Complete bibliographic databases. The original studies, published in French or English between 2007 and 2017 and peer-reviewed, were used in the review.

To achieve the second objective, key actors were consulted during two laboratories of ideas. The participants were selected for their expertise or work experience in the field. During the laboratories of ideas, the project coordinator briefly explained the study and the participants' role in this consultation process. Members of the research team then presented the knowledge synthesis and an integrative diagram illustrating its key elements. Participants were invited to comment on the synthesis for each extreme weather event and to complete the information based on their experience and knowledge. Finally, participants had to share their concerns and the issues related to each event and propose avenues for research and intervention for each event.

To achieve the third objective, a prioritization exercise to establish an order of priority for avenues for research and intervention was carried out with the members of the monitoring committee and the project committee. This exercise was conducted through a phone call during which all members were invited to anonymously evaluate these avenues based on four criteria: relevance, urgency, feasibility, and impact.

The main results of this project are a knowledge synthesis accompanied by an integrative diagram illustrating the psychosocial effects experienced by workers following four extreme weather events, as well as a list of avenues for research and intervention that respond to Québec's workplace and public health needs.

The knowledge synthesis and integrative diagram were developed using 30 original studies, two literature reviews, and the knowledge shared by the participants of the laboratories of ideas. This synthesis revealed a number of findings.

The extreme weather events studied can have psychosocial effects on workers, but our knowledge of these effects varies greatly by event. The psychosocial effects among workers were most well documented in the scientific literature for storms, less well documented for floods and forest fires, and scarcely documented for heat waves.

The knowledge on the types of workers who have experienced psychosocial effects varies. Frontline workers (such as municipal employees, police officers, firefighters, health professionals who work with emergency victims, public works employees, etc.) and farmers are among the most studied groups of workers.

While little covered by the scientific literature, negative psychological effects (burnout, fatigue, psychological distress, anxiety, anger, sadness) were reported more often by workers than social impacts.

Organizational risk factors (e.g., work overload or a lack of training, material resources or available staff) and personal risk factors (e.g., being the victim of an emergency, lack of contact with family members) were identified that are common to several events and types of workers and which exacerbated psychosocial effects. Certain protective factors were also identified, such as well-being (e.g., appreciation or gratitude, individual resilience, etc.), social support, and collective efficacy.

This review has emphasized the importance of consulting key actors to improve the knowledge from the scientific literature, as these consultations made it possible to identify other vulnerable workers, learn more about the characteristics of certain extreme weather events, and learn that the psychosocial effects following these events can be positive.

In light of these findings, 21 avenues for research and intervention for Québec were determined from discussions with participants in the laboratories of ideas. The objective of the vast majority of avenues was to acquire further knowledge on the psychosocial effects experienced by workers exposed to extreme weather events, which suggests that this topic remains new in Québec and around the world, and that the knowledge must be developed before proposing adaptive measures. The greatest number of avenues were proposed for flooding (seven avenues). Six were proposed for heat waves, two for storms, and none for forest fires, even though participants were queried on the topic.

The prioritization exercise carried out with the project monitoring committee demonstrated that the psychosocial effects experienced by workers following flooding are a subject of interest for Québec.

1 BACKGROUND

In 2017, the Institut national de santé publique du Québec (INSPQ) was mandated by the ministère de la Santé et des Services sociaux du Québec (MSSS) to conduct research on the psychosocial vulnerability of workers in relation to climate change (CC).

This mandate was part of the implementation of Action 26.3 of the Government of Québec's 2013-2020 Climate Change Action Plan (hereinafter the "2013-2020 CCAP"). This action specifically addresses reducing psychosocial effects related to extreme weather events (EWEs). It is one of a series of actions outlined in the 2013-2020 CCAP that fall under the responsibility of the MSSS and that generally aim to support adaptation research and prevent or limit illnesses, injuries, mortality, and impacts (INSPQ, 2019).

The MSSS's mandate for the INSPQ is of particular importance for Québec. Firstly, it is crucial to study the health impacts of EWEs since CC is projected to increase the frequency and severity of some of these events (Ouranos, 2015). In Québec, climate predictions suggest that the duration of heat waves will increase and that variations in rainfall patterns will increase the likelihood of flooding in some regions (Ouranos, 2015). An increase in the frequency and severity of forest fires is also projected, partly caused by the increased number of drought periods expected with CC. Moreover, the frequency and severity of some storms will increase. Current climate knowledge does not allow for precise predictions about ice storms and post-tropical cyclones (hurricane "remnants"), but some preliminary studies suggest an increase in the frequency and intensity of storms. Climate models now confirm that, with CC, post-tropical cyclones will bring greater quantities of precipitation and those reaching the Gulf of St. Lawrence will contribute to the risks of erosion and of submersion of coastal regions (Ouranos, 2015).

Secondly, developing knowledge on the psychosocial effects experienced by workers following EWEs is equally important for Québec as the literature on this topic is incomplete, both here and around the world. The international scientific community has been interested in the impacts of CC on workers' health for nearly a decade, but has mainly documented physical impacts (like heatstroke and infectious zoonotic diseases). No publication has specifically addressed the psychosocial effects of EWEs experienced by workers and measures to implement to prevent them.

Nevertheless, some examples of these types of effects, and psychological effects specifically, are mentioned in work published in France and in Québec. In France, a collective expert report by the Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail (ANSES) discussing CC-related risk assessment of workers' health (ANSES, 2018), indicated that the increase in the number or intensity of some EWEs may in turn increase the number of field interventions by actors in crisis management (also called "frontline workers," which includes civil security, first responders, cleaning staff, etc.). These increased interventions could cause physical

and mental exhaustion for workers. The report also mentioned that this increase in EWEs could also increase the workload and sense of job insecurity for some workers, like farmers and employees of small businesses. Both are psychosocial risk factors associated with the occurrence of psychological and physical health problems for workers (INSPQ, 2016). In Québec, a knowledge synthesis published by the Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST, 2012) mentions that some events related to CC can have psychological effects on workers. Three different situations related to psychological health are presented in this synthesis: 1) storms on the scale of Katrina (2004) can affect the mental health of workers involved in responding to the event, particularly by triggering post-traumatic stress disorder (PTSD); 2) heat waves can cause physical discomfort and alter workers' emotional states due to excessive exposure to heat and the resulting increase in body temperature; and 3) deleterious climate activities on natural resources can cause job insecurity, work dissatisfaction, and physical and mental health problems for workers whose livelihoods are based on the exploitation of these resources and who depend on them for financial survival.

This report documents the results of an exploratory study conducted by the INSPQ in response to the MSSS's mandate. Given the lack of knowledge on the psychosocial effects of CC on workers, the aim of this exploratory study is to briefly examine the literature and knowledge of key actors in order to propose more significant next steps for research projects that respond to Québec's workplace and public health needs and issues. This exploratory study focused more specifically on the psychosocial effects caused by four EWEs that will be exacerbated by CC in Québec: heat waves, flooding, forest fires, and certain types of storms.

2 OBJECTIVES

The general objective of this project was to detail the state of knowledge and identify avenues for research and intervention that respond to the needs of Québec workplaces and public health.

More specifically, the project's aims were the following:

- 1 Establish a knowledge synthesis on the psychosocial effects experienced by workers following heat waves, flooding, storms, and forest fires;
- 2 Validate this synthesis, identify gaps, and determine the priority issues for workplaces and for public health as well as avenues for research and intervention;
- 3 Establish an order of priority for avenues of research and intervention.

An auxiliary objective of this project was to promote collaboration between a wide range of occupational health actors on the issue of negative psychosocial effects of EWEs on workers.

3 DEFINITIONS

To facilitate the understanding of this study, the authors deemed it important to define certain key terms. Psychosocial effects, workers, and the four EWEs (heat waves, floods, storms, and forest fires) are defined below.

Psychosocial effects:

The term “psychosocial effects” has various definitions. In the context of this study, the decision was made to adopt the definition set out in the INSPQ’s *Guide de soutien destiné au réseau de la santé* [support guide for the healthcare system], which discusses assessing the social impacts of environmental projects (Bouchard-Bastien et al., 2014). In the guide, the term “psychosocial effects” is split into two separate concepts: psychological effects and social impacts. The authors justify this choice as the term “psychosocial effects” could create misunderstanding, as it combines two distinct concepts and has various definitions.

In this study, like in the aforementioned guide, psychological effects are effects on an individual’s psychological integrity. Examples include decreased satisfaction, a decline in well-being, anxiety, anguish, despair, anger, and despondency.

Some psychological effects can also develop into a mental disorder when a certain threshold of psychological suffering is reached and accompanied by a significant deterioration in daily functioning. In the Diagnostic and Statistical Manual of Mental Disorders (DSM-V), a mental disorder is defined as “a clinically significant behavioral or psychological syndrome or pattern that occurs in an individual and that is associated with present distress (e.g., a painful symptom) or disability (i.e., impairment in one or more important areas of functioning) or with a significantly increased risk of suffering death, pain, disability, or an important loss of freedom” (APA, 2013). Depression and PTSD are examples of mental disorders.

In the current study, as is the case in Bouchard-Bastien et al. (2014), social impacts refer to effects on groups that can lead to changes in the daily lives of individuals (lifestyle), the culture (values, culture clash, marginalization), the community (cohesion, resources, social tension, violence), or the political system (Bouchard-Bastien et al., 2014).

Finally, as the current study is exploratory, only the negative psychosocial effects of EWEs were studied.

Workers:

In this study, the term “worker” refers to any person who carries out work or dedicates themselves to a task, whether manual or intellectual, paid or unpaid. In this context, regular and casual employees, self-employed workers, contractors and subcontractors, apprentices, interns, students, volunteers, labour hired by placement agencies, seasonal workers, and at-home workers are all considered workers.

This definition is more inclusive than the one set out by Québec's Act Respecting Occupational Health and Safety (Gouvernement du Québec, 1979). It was chosen due to the exploratory nature of this study and the objective of documenting potential psychosocial effects experienced following one of the four EWEs by any working individual.

For informational purposes, the definition used in this study is inspired by the one chosen by the Australian Government in its Work Health and Safety Act 2011 (Australian Government, 2011).

Heat waves:

For the purposes of this study, a heat wave is broadly defined as a period during which the temperature is abnormally high and uncomfortable. This definition comes from the glossary published by the Intergovernmental Panel on Climate Change (IPCC) in 2014 (see GEIC, 2014 in the References section).

Therefore, in this study, a "heat wave" may be a heat wave proper, a period of oppressive heat, or a period of extreme heat, even if the exact definitions of these terms vary.¹

Floods:

For the purposes of this study, the definition of "flood" comes from the IPCC's glossary (2014 [see GEIC, 2014 in the References section]). A flood is thus defined as the overflowing of the normal confines of a stream or other body of water, or the accumulation of water over areas not normally submerged. Floods include river (fluvial) floods, flash floods, urban floods, pluvial floods, sewer floods, coastal floods, and glacial lake outburst floods.

Various phenomena can cause flooding. Some are related to CC (e.g., accumulation of atmospheric moisture, variations in projected rainfall regimes), while others are not (e.g., waterway obstructions, land cave-ins). The present study does not distinguish between them.

Storms:

For the purposes of this study, the definition of "storm" comes from an INSPQ scientific report published in 2006 on extreme climate events and health. Storms thus include extreme summer weather phenomena (such as cyclones, lightning, tornadoes, tropical storms, and hurricanes) and extreme winter weather phenomena (such as windstorms and extreme hail, freezing rain, and snow).

¹ **Heatwave:** refers to a period of a minimum of three consecutive days during which the temperature reaches or exceeds 30°C during the day (Santé Montréal, 2016). **Oppressive heat:** Environment Canada issues a heat warning when the temperature is forecasted to be 30°C or warmer and the humidex value is forecasted to be 40 or higher (MSSS, 2018). **Extreme heat:** this expression is used by public health authorities. Concretely, extreme heat warnings are issued by the INSPQ and public health units, leading to the deployment of a plan to help mobilize health workers. The thresholds for these warnings are specific to each region. In general, depending on the region, the weighted average maximum temperatures forecasted for the next three days must be between 31 and 33°C and the minimum temperatures between 16 and 20°C.

Forest fires:

For the purposes of this study, the term “forest fire” refers to both forest fires and wildland fires. Natural Resources Canada (2017) defines forest fires as any unplanned fire that consumes vegetation and organic matter from natural material in forested land, and defines wildland fires as any fire that occurs in forests, shrub lands, and grasslands (Ressources naturelles Canada, 2017).

4 METHODOLOGY

The present study was conducted between October 2, 2017, and May 15, 2018.

The study was carried out in three phases. The first phase was a rapid synthesis of knowledge conducted using a systematic review methodology on the psychosocial effects experienced by workers due to heat waves, flooding, storms, and forest fires. The second phase consisted of consultations with key actors to 1) validate the knowledge reviewed and identify gaps, 2) identify challenges for workplaces and for public health, and 3) to determine avenues for research and intervention to better protect Québec workers. The third phase was a prioritization exercise conducted to establish an order of priority for the previously identified avenues of research and intervention.

Throughout the study, the research team was supported by a monitoring committee. Monitoring committee members were consulted at various key moments to discuss the methodology, key actors involved, and the prioritization of research avenues. The monitoring committee members are presented in Appendix 1 and their contributions are detailed below.

4.1 Knowledge synthesis

The strategy used for the synthesis was defined with an INSPQ librarian. The literature search took place between October 18 and November 16, 2017.

4.1.1 Research question

The literature review aimed to address the following question: what are the negative psychosocial effects of heat waves, flooding, storms, and forest fires on workers?

Search strategy

The MEDLINE, Embase, Psychology & Behavioral Sciences Collection, PsycInfo, SocINDEX, and Environment Complete databases were searched using three keyword categories corresponding to health effects (negative psychological effects and negative social impacts), exposure to EWEs (heat waves, flooding, storms, and forest fires), and the population studied (workers). The various search algorithms for the databases are presented in Appendix 2. This strategy was supplemented by a review of the bibliographic references in the selected articles.

4.1.2 Inclusion and exclusion criteria

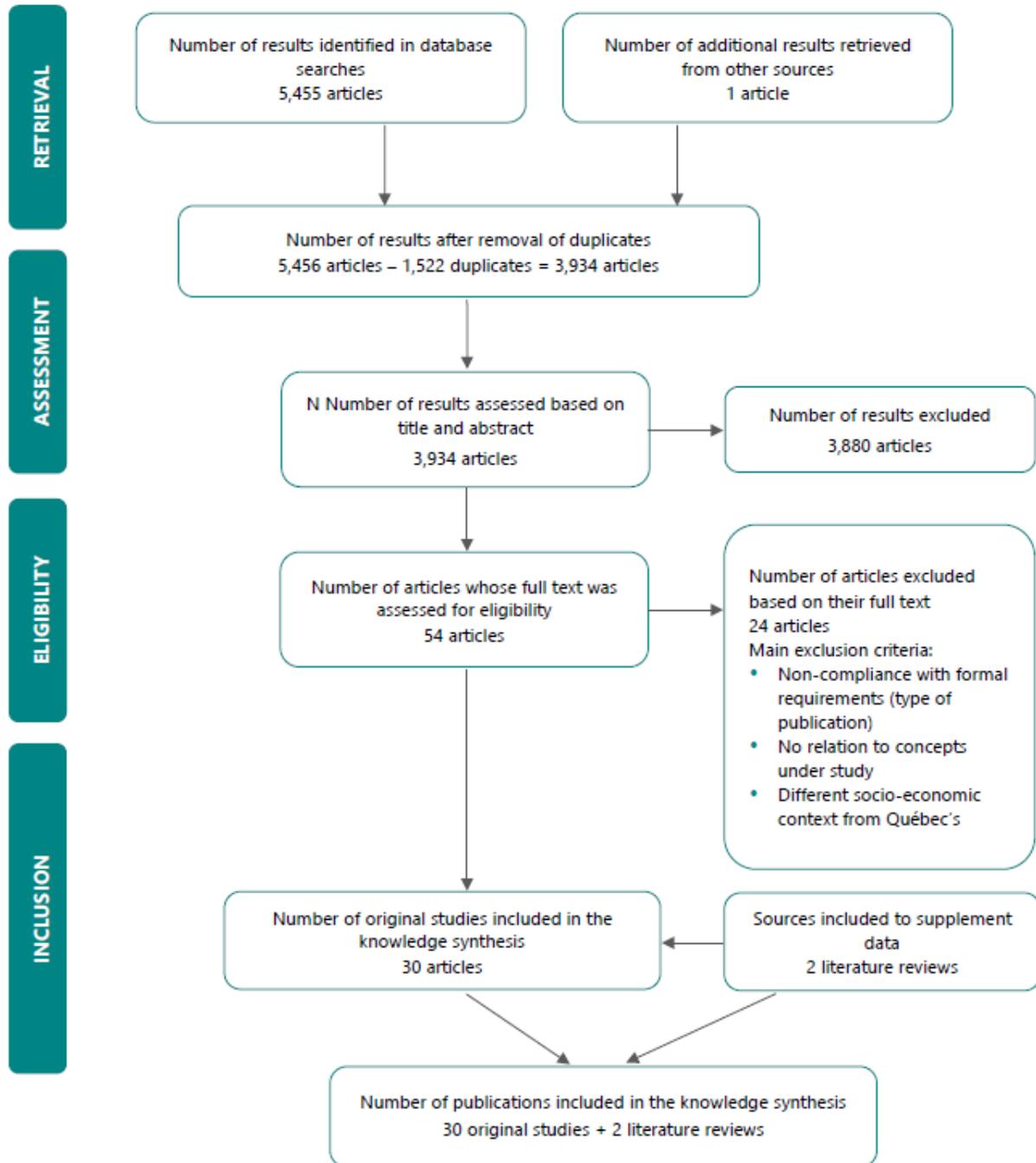
Inclusion and exclusion criteria were defined to select publications. Only peer-reviewed studies published in French or English between 2007 and 2017 were retained. Publications that focus on population groups other than workers, that report non-original results, that took place in a socio-economic context that differs from Québec's, that focus only on physical health effects, that cover non-climate events, or that specifically document workers' resilience and adaptiveness were excluded.

Literature reviews were sought only when they dealt with a topic not addressed by original studies.

Figure 1 describes the literature search and selection process. A total of 30 original articles were retained for the synthesis, as well as two literature reviews.

For every publication retained, the types of EWE, psychosocial effects, the types of vulnerable workers, and certain personal and organizational risk factors and protective factors were identified.

Figure 1 Illustration of the literature search and study selection process



4.2 Development of an integrative diagram of the knowledge

A content analysis was conducted to synthesize the data from the selected scientific articles. This analysis was conducted by a single analyst, and the results and key elements from this analysis were placed in an integrative diagram. This qualitative method of analysis includes three main steps: a pre-analysis phase, an itemization (coding) phase, and a data interpretation phase (Creswell, 1998; Robert and Bouillaguet, 1997; Savoie-Zajonc, 2000).

In the pre-analysis stage, an initial reading of the corpus of selected studies was performed to identify recurrent themes (factors, variables, concepts). For this initial reading, the analyst kept in mind a few theoretical frameworks likely to shed light on the psychosocial effects of EWEs. To this end, the analyst proceeded on the assumption that elements from clinical research (American Psychiatric Association, 2013) as well as various models would offer relevant avenues of interpretation. Models considered at this stage included transactional (Lazarus, 1999), diathesis–stress (Sigelman and Rider, 2009), psychosocial (Brown, 1997), and biopsychosocial (Benquin, 2010); these models have been developed to account for, respectively, stress states, the development of psychopathologies, the development of depression, and the maintenance or deterioration of health.

At the end of the pre-analysis phase, four main themes associated with the phenomenon were identified: 1) moderating factors (factors that predate the EWE and that are particular to the worker); 2) buffering factors (factors that occur in the hours or days following the EWE and that lessen the shock); 3) collateral events (events that occur as a result of the EWE and that affect the worker personally outside of their duties); and 4) psychosocial effects (the psychological effects and social impacts of the EWE experienced by the worker).

The themes thus identified were then used to create a grid for textual data analysis. This grid was used to code the textual data. Each document was reread in its entirety alongside the analytical grid. For a given document, any passage, word, or expression that matched one of the major themes was reported in the grid under the appropriate column. After the textual data was processed, the analyst turned to the above-mentioned theoretical models and clinical knowledge to diagram the temporality of the factors' appearance and the links between them.

4.3 Consultations with key actors

Key actors were consulted in two discussions of ideas held February 14 and March 8, 2018. The discussions of ideas were held in the Montréal and Québec City offices of the INSPQ.

4.3.1 Participant selection

The laboratories of ideas participants were chosen in collaboration with the monitoring committee and in consideration of the main sectors identified in the literature review. They were invited to participate on the basis of their expertise in occupational health prevention, public health, and psychology. Other actors including field workers who had already been exposed to one or several EWEs were also invited to participate. At the request of the monitoring committee, particular efforts were made to include participants able to report on the realities of vulnerable workers, including seasonal workers, immigrant workers, students, and employees of small businesses.

Lastly, the members of the monitoring committee participated in one of the two discussions of ideas. Participants also included representatives from the following organizations and occupational groups:

- Association paritaire pour la santé et la sécurité du travail – Secteur des affaires sociales;
- Association paritaire pour la santé et la sécurité du travail – Secteur affaires municipales;
- Confédération des syndicats nationaux;
- Direction de la santé publique des Laurentides of the Centre intégré universitaire de santé et de services sociaux (CIUSSS) des Laurentides;
- Direction de la santé publique de Montréal of the CIUSSS du Centre-Sud-de-l'Île-de-Montréal;
- Fédération des travailleurs et travailleuses du Québec – Construction;
- Institut national de santé publique du Québec;
- Institut de recherche Robert-Sauvé en santé et en sécurité du travail;
- Service intervention et formation aquatique;
- Canadian Union of Public Employees – Québec;
- Union des producteurs agricoles;
- Université du Québec à Montréal.

4.3.2 Laboratories of ideas

The laboratories of ideas were three hours long. Each laboratories of ideas opened with the project coordinator briefly outlining the objective of the consultation and the participants' role. Next, members of the research team presented the knowledge synthesis, detailing the content of three articles retained in the synthesis in order to provide participants with concrete situations, and then concluded their presentation with the integrative diagram.

Following their presentation, participants were asked to comment on the knowledge synthesis and supplement it with their experience and knowledge. The participants then shared their concerns and issues related to each EWE and proposed avenues for research and intervention for each EWE.

The laboratories of ideas were recorded, and two members of the research team took notes throughout.

4.3.3 Summary of the laboratories of ideas

Following the laboratories of ideas, the comments and new information provided by the participants were added to the knowledge synthesis and the integrative diagram.

Concerns, issues, and avenues for research and intervention were summarized and condensed into 21 proposals, which were submitted to the monitoring committee members for a prioritization exercise.

4.4 Prioritization exercise

The prioritization exercise was conducted by members of the monitoring committee during a phone meeting and via email on May 7, 2018.

During a phone meeting, each member of the committee was asked to evaluate the avenues for research and intervention by considering the following four criteria: relevance, feasibility, impact, and urgency, rating each on a three-point scale (1 = strong, 2 = medium, 3 = weak). The details of the evaluation criteria were explained to the members of the monitoring committee.

- Relevance was to be evaluated in relation to psychosocial effects.
- Feasibility was to be evaluated based on whether the research or intervention could be carried out by public health actors.
- Impact was to be evaluated based on the number of workers the avenue would protect, geographic coverage, etc.
- No clarification was provided for urgency.

To facilitate the prioritization exercise, an evaluation grid was provided to members of the monitoring committee prior to the meeting; they were asked to fill it out during the meeting based on the instructions provided by facilitator (see grid in Appendix 3).

The exercise was conducted anonymously, meaning participants did not discuss their ratings with each other. The meeting facilitator presented the first avenue to participants and explained its context, i.e., why this avenue was proposed during the laboratories of ideas. Participants were

then asked to rate it according to each of the evaluation criteria using the grid provided. The facilitator then presented the second avenue and its context, and participants were again asked to provide a rating for each evaluation criterion. The process was repeated for all 21 avenues. At the end of the exercise, participants calculated the sum of the ratings of the four criteria for each avenue and sent their evaluation to the facilitator by email. The results of the participants' evaluations were pooled to calculate an overall rating for each avenue.

The exercise was carried out with four members of the monitoring committee. The research avenue rated to have the highest priority was thus the one with the lowest overall score; for example, a rating of 16 would mean that all members of the monitoring committee gave that avenue a one ("strong") for each of the four evaluation criteria. Conversely, the avenue with the lowest priority rating was the one with the highest overall score: e.g., a rating of 48 would mean that all members of the monitoring committee gave that avenue a three ("weak") for each of the four evaluation criteria.

5 RESULTS

This section presents the knowledge synthesis and integrative diagram. Next, the avenues for research and intervention identified by the laboratories of ideas participants are reported along with their prioritization as established by the monitoring committee.

5.1 Knowledge synthesis

The knowledge synthesis presented in this section is based on observations from the selected publications and the laboratories of ideas participants' reports of their field experience.

Overall, the selected studies were concerned with high intensity EWEs.² The majority of the selected studies pertained to storms (23 from the United States and two from Canada), while three pertained to flooding (two from Australia and one from Britain), and two to forest fires (one from Canada and one from Australia). No studies on the impacts of heat waves on workers could be found, but two literature reviews were selected to fill this gap.

The selected studies mainly documented the effects on both volunteer and paid workers deployed to help affected communities (police officers, firefighters, social workers, and public or charitable organization workers, etc.). The methodological approaches used in these studies varied (19 were quantitative, six qualitative, and five mixed-method), and with few exceptions, the studies were cross-sectional. A brief description of each selected study (type of study, data collection period, countries or regions studied, number of workers, and trades or occupations studied) is presented in Appendix 4.

The following sections present the main findings that emerged from the scientific literature on storms, flooding, heat waves, and forest fires (subsections 5.1.1 to 5.1.4). These observations are supplemented by comments from the laboratories of ideas participants, found at the end of each subsection.

5.1.1 Storms

A total of 25 studies documenting the psychosocial effects experienced by workers exposed to storms and their consequences were selected: 23 studies from the United States on hurricanes and tropical storms (including Hurricane Katrina, Hurricane Rita, Post-Tropical Cyclone Sandy, etc.) and two Canadian studies on an ice storm. These studies documented the psychosocial effects one week to six years after the event.

² The meaning of "disaster" here comes from the definition of a "major disaster" provided in the Civil Protection Act (Gouvernement du Québec, 2018; in French: Loi sur la sécurité civile): "an event caused by a natural phenomenon, a technological failure or an accident, whether or not resulting from human intervention, that causes serious harm to persons or substantial damage to property and requires unusual action on the part of the affected community, such as a flood, earthquake, ground movement, explosion, toxic emission or pandemic."

Hurricanes and post-tropical storms

Coverage of the events in the scientific literature

The hurricanes in question in the works selected were intense, devastating weather events, characterized by violent winds and heavy rain. They strongly affected the regions and communities that were hit, disturbing their physical and social environments. Many people were victims of and displaced by these disasters, and many injuries and deaths were also reported. Disruptions to the social order were observed in some communities (looting, conflicts). Residences, buildings, and infrastructure were damaged or destroyed, and access to various utilities and networks (e.g., transport, communications, electricity) and resources (e.g., water, food, fuel) was limited or absent for an indefinite period. The workers operating in these contexts, whether paid or volunteer, were sometimes victims or survivors of the hurricanes themselves. Overall, the selected studies described the working conditions and the personal, professional, and social consequences of these workers' exposure to the hurricanes.

Effects on first responders

The literature reviewed highlighted the major psychosocial effects that first responders (i.e., police officers, firefighters, municipal workers, public health workers, volunteers providing services to victims) may experience due to hurricanes.

Many studies suggest that, following a hurricane, first responders are at an increased risk of presenting symptoms typical of a negative stress response (Clukey, 2010), more severe symptoms consistent with post-traumatic stress disorder (PTSD) (Battles, 2007; Osofsky et al., 2011; Fullerton et al., 2013; McCanlies et al., 2014), and depression (Tak et al., 2007; West et al., 2008; Osofsky et al., 2011; Fullerton et al., 2013, 2015; Nicdao et al., 2013). For example, West et al. (2008) report that out of 912 police officers dispatched to maintain public order and provide relief to victims during Hurricane Katrina, 119 officers (14%) presented symptoms consistent with PTSD and depression eight weeks after the event. Fullerton et al. (2013) demonstrated an increase in the use of tobacco and alcohol by public health workers, in addition to an increased prevalence of PTSD and depression, during the several hurricanes and tropical storms that occurred in the state of Florida in 2014. Further, Osofsky et al. (2011) showed that responding to hurricanes can also lead to partner conflict lasting several months after the event.

In addition, McKibben et al. (2010) revealed that sleep disturbances and symptoms of hypervigilance were reported among public health workers following the 2004 hurricane and storm season in the state of Florida. According to their study, these effects resulted in a decrease in day-to-day functioning and work performance that persisted nine months after the event. In addition, two studies showed that police officers and nurses reported experiencing role conflict both during hurricanes and the lead-up to them (Adams and Turner, 2014; Raveis et al. 2017). In other words, these workers felt divided between their work duties and family

responsibilities, and felt their employers' needs and expectations to be incompatible with those of their family.

Beyond these effects, several personal and professional risk factors were identified among first responders deployed. These factors contribute to an increased likelihood of symptoms of psychological distress in workers following a hurricane. Factors highlighted in the studies reviewed include being the victim of the disaster oneself (Fullerton et al., 2013), work overload (Fullerton et al., 2013), and lack of organizational support or supervision (Tak et al., 2007; Yarbrough et al., 2007). Police officers who had been injured in a physical assault on the job, who had participated in crowd control or protection, or whose families had been injured as a result of the hurricane were more likely to experience symptoms of PTSD (West et al., 2014). The same study found that symptoms of depression were more likely among officers who had been injured in a physical assault not related to their duties, who had little contact with their family during the event, who have a family member who suffered injuries, or whose residence became uninhabitable as a result of the hurricane.

Conversely, some factors emerged as contributing to reducing the risk of suffering psychosocial effects. In particular, studies have suggested that factors related to well-being (e.g., recognition or gratitude, life satisfaction, resilience) (McCanlies et al., 2014; Leppma et al., 2017), social support (Adams and Turner, 2014; Raveis et al., 2017), and collective efficacy (Fullerton et al., 2015) contribute to mitigating hurricanes' negative impacts on workers.

Effects on psychosocial care professionals

Several authors have reported the risk of vicarious trauma, compassion fatigue, burnout, or substance abuse in psychosocial care professionals responding to hurricanes (Lemieux et al., 2010; Culver, McKinney, and Paradise, 2011; Tosone, McTighe, and Bauwens, 2015; Bauwens and Tosone, 2014; Lambert and Lawson, 2013; Prost, Lemieux, and Ai, 2016). As the therapeutic work of psychosocial care professionals is psychologically demanding, it is in fact likely to cause them psychological distress. Other personal and occupational risk factors were also presented in studies of psychosocial care professionals. A personal history of past traumatic events, personal exposure to the disaster (being a victim of the disaster oneself), work overload during the event, fewer years of work experience, and a lack of specific training in one's role during traumatic events all seem to increase these workers' risks of suffering psychosocial effects during hurricanes.

Similarly, Dass-Brailsford and Thomley (2012) have suggested that several factors may have contributed to reducing the risk of vicarious trauma following Hurricane Katrina: disaster response training, prior field experience, working with experienced volunteers, debriefing sessions at the end of the workday, well-defined work hours, and implementing self-care strategies (e.g., participating in social activities). The responders in this study did not themselves

live in the disaster-affected area and their involvement in the management of this disaster was short-term, which may have influenced their level of vulnerability to the effects of the disaster. Other actors mentioned factors that positively contributed to the psychological health of psychosocial care professionals, such as various learning and coping strategies (Clukey, 2010; Lambert and Lawson, 2013; Leppma et al., 2017).

Effects on workers in educational institutions

Two studies highlighted the experiences of school staff in communities devastated by Hurricane Katrina or Hurricane Rita (Broussard, Myers and Meaux, 2008; Ward and Shelley, 2008). The staff in these articles were nurses in the former, and administrators and teachers in the latter. Some staff had been working in disaster-affected areas and experienced workplace relocation, separation from their families, job loss, or damage to their home, etc. Other staff had not been working in disaster-affected areas but were involved in caring for evacuees or experienced profound changes in their workplace and practices. While not victims of the disaster themselves, some of these workers experienced worry over the evacuation of their family members living in disaster-affected areas. All workers reported having been affected both personally and professionally by one or more hurricanes. Some psychological impacts were reported in these studies, including worry, concerns about job security, psychological distress, and burnout. These impacts were mainly associated with material, human, and financial losses (especially for workers living in disaster-affected areas), added workload, disruptions to their working environments and working conditions caused by the hurricane, and an emotionally disturbed or traumatized clientele, among others.

Ice storm

Extent of coverage of the event in the scientific literature

Two papers describe the psychological and social consequences on workers of the January 1998 ice storm in northeastern North America. The first focused on Québec workers who provided a variety of support services to victims of the ice storm (Maltais and Robichaud, 2009); the second focused on Ontario farming families (Sutherland and Glendinning, 2008) during and after the ice storm. These two studies showed that the ice storm was a complex event that had a series of significant consequences, including massive, long-lasting power outages that affected public and private services. These outages caused an upheaval in the usual routines of the workers studied and were also a source of difficulty. In addition, it is important to note that all these workers were also themselves victims of the storm.

Effects on first responders

As mentioned above, Maltais and Robichaud (2009) examined first responders (e.g., police officers, firefighters, social workers, nurses, home care workers, facilitators, etc.). The authors reported that the ice storm had repercussions on these first responders' physical and

psychological health and that these repercussions were felt both at home and at work. In this study, workers reported feeling worried, powerless, or like they were letting their loved ones down when they were at work. These workers also mentioned experiencing fatigue, overwork, and muscle and respiratory health problems, as well as family conflicts, tensions, and difficulties (including separation and divorce). Some stated having experienced a loss of enthusiasm for social or professional activities, increased emotional sensitivity or perceived vulnerability, feeling empty or lonely when returning to their usual activities, or bitterness resulting from a lack of consideration of or acknowledgement for the work they performed during the disaster. The authors also reported that these effects could continue to be experienced over the longer term. For example, the workers interviewed reported many problems, including work overload and the incidence or exacerbation of conflicts (between colleagues or partner organizations) when returning to their jobs after the storm. Some also mentioned a lack of motivation, decrease in their performance, and, to a lesser extent, resigning from their position after returning to work post-disaster. Lastly, it is important to note that some effects of the ice storm, including psychological and physical fatigue and exhaustion, persisted for first responders in the year following the storm.

Again according to Maltais and Robichaud's study (2009), responders described various factors associated with the performance of their duties or their working conditions that increased the negative effects they experienced. In this respect, first responders mentioned their demanding schedule (extended shifts, atypical hours, little or no respite, etc.), constraints in carrying out tasks (rapid decision-making, occasionally arduous physical effort, etc.), a lack of staff, a lack of volunteer training, a more demanding clientele in temporary shelters (more dependent or more difficult to manage), the lack or inadequacy of material resources in these centres (including communication resources), uncomfortable working conditions (e.g. cold, wet, dark, poorly ventilated) or risky working conditions (exposure to various physical, chemical, and biological hazards) as well as difficult conditions when travelling to the homes of disaster victims.

Impacts on farming families

Sutherland and Glendinning (2008) studied farming families. Their study focused on 171 households who agreed to answer a questionnaire and who were living in a variety of counties in Eastern Ontario during the 1998 ice storm. The authors reported that during the storm, these families initially faced a disruption to their daily routines and a significant and ongoing work overload. What's more, due to communication network outages, a number of farmers reported feeling isolated and uncertain about the future of their businesses. The study revealed that power outages during the storm were a major upset for farmers. It is important to mention that these 171 households confirmed they were without power for periods of two to 25 days, and 90% of these families had to acquire a generator to supply power to their farm and maintain their activities.

Sutherland and Glendinning (2008) also reported a significant increase in the prevalence of symptoms of an adverse stress reaction among farmers according to the duration of the power outage: 49% reported experiencing stress during an outage of two to seven days and 76% reported experiencing stress after an outage of 15 or more days. The study highlighted how farm owners whose businesses rely on electrical power, such as dairy farms, were particularly affected by this problem. As a result, stress was significantly higher among dairy farm operators compared to owners of other farms (OR = 2.17, $p = 0.03$). Finally, the study also revealed that a significant proportion of farmers reported having incurred financial losses and extensive material damage.

Experiences specific to workers in Québec

In addition to the study by Sutherland and Glendinning (2008), laboratories of ideas participants mentioned that storms (hail and ice storms, for example) are also especially disruptive for agricultural producers in Québec as well, because their land, crops, and facilities can incur significant damage. These events can result in financial losses and unexpected costs that are generally not covered by insurance.

Other participants also mentioned that some storms in Québec create difficult working conditions, especially for electrical power line workers. Following the 1998 ice storm, electrical power line workers faced a sudden and prolonged work overload leading to long work shifts and fatigue. These power line workers were also concerned about their more dangerous work setting, as the outdoor environment was icy and crampons did not always provide the traction needed to ensure their safety.

Lastly, laboratories of ideas participants raised an interesting point that had not been identified in the literature review: civilians taking out their frustration on public works employees. In this regard, they mentioned that after heavy snowfall and freezing rainfall, municipal employees and subcontractors can be subject to threats from civilians who are dissatisfied with the quality or speed of snow removal or spreading of abrasives. The participants confirmed that such reactions may have negative effects on the psychological health of their colleagues.

5.1.2 Flooding

Three selected publications focused on the psychosocial effects of flooding on workers. These studies documented the psychosocial effects occurring over periods of one to 36 months following the events. The workers studied were individuals providing frontline services such as municipal workers, charitable organization volunteers (Carroll et al., 2010), police officers (Biggs, Brough, and Barbour, 2014), and women agricultural producers (Carra and Curtin, 2017). The participants of the laboratories of ideas supplemented this knowledge by providing examples of effects experienced by agricultural workers in Québec and by psychosocial care professionals.

Description of the scale of the events documented in the scientific literature

The selected publications focused on major flooding in the United Kingdom and Australia, where the impacts on communities were great. During these floods, people were directly affected and displaced, injuries and deaths were observed, buildings and infrastructure were damaged, and water, power, and communication services were disrupted. In these studies, the workers were victims themselves, as they lived, worked, or operated their businesses in the flooded areas.

Psychosocial effects and associated factors among frontline workers

Carroll et al.'s study (2010) focused on frontline workers and volunteers who were victims of major flooding in the United Kingdom in 2005. In this study, these workers described themselves as very physically tired and psychologically exhausted during the floods. These effects can be explained by the lack of personnel (as the homes of some workers were flooded and these workers were temporarily unable to show up to work) and the work overload resulting from these staff shortages. The difficulties faced by workers were also explained by the workers' exposure to the victims' psychological and emotional distress and from hearing about victims' experiences and trauma. Finally, these impacts were also explained by the fact that some workers felt they lacked the experience or training necessary to offer victims adequate psychological support.

Biggs et al.'s study (2014), which focuses on police officers who responded during a major flood in Australia in 2010 to 2011, underscores the psychological effects and social impacts on this group of workers. In this study, 1,623 police officers responded to an online survey on two separate occasions: around ten months before the flooding and around one month afterwards. The survey questions covered demographics, characteristics of their work, measures of psychological effects and social impacts (such as the worker's perception of the supportiveness of their workplace culture, intrinsic satisfaction, commitment to their work, psychological fatigue, etc.), and their involvement during the flooding. This study emphasized that the varying implications of police work during floods can lead to different psychosocial effects. For example, the authors observed that police officers' involvement in major operations or communications was associated with high levels of intrinsic worker satisfaction and work commitment and with lower levels of intention to resign, which was not observed among police volunteers or officers assigned to frontline operations.

Both studies (Carroll et al., 2010; Biggs et al., 2014) point to factors that aggravated the effects experienced by the workers during the floods. These include a flooded and relocated temporary workplace, a lack of resources, exceptional work overload due to higher absenteeism, the reorganization of work hours (overtime and atypical schedules) that left little room for rest periods, and loss of or damage to personal items.

Impacts on agricultural producers

Carra and Curtin (2017) examined the psychosocial effects on women agricultural producers following major flooding in Australia in 2010 to 2011. The authors met individually with six producers who had over 20 years working in their field to document their experiences during and after the floods. Among their findings were strong feelings of powerlessness in the farmers during the floods. The feelings of powerlessness arose out of a perceived loss of control of the situation, including the inability to protect their livestock, crops, personal belongings, property, and families. These workers reported that their feelings of powerlessness also led to sadness, anger, and distress.

The study also reported that significant psychological effects and social impacts were experienced nearly three years after the flooding. For example, the producers reported feeling distressed by the profound social and environmental changes in their communities. They also expressed struggling to deal with a number of personal and professional changes, such as overcoming financial losses, rebuilding their agricultural business, and providing support to other communities while experiencing difficult thoughts and emotions themselves.

Experiences specific to workers in Québec

During the laboratories of ideass, participants confirmed that agricultural producers in Québec experience psychosocial effects during flooding as it affects their work. Flooding causes job losses and revenue losses as it can lead to a need for more costly forms of pesticide application, such as aerial application, as the fields are no longer accessible by land routes. These are particularly harmful consequences as most agricultural producers in Québec are self-employed. Moreover, their crops may be subject to multiple EWEs in a given year (flooding, heat waves, heavy rainfall, hail, etc.). Therefore, in addition to the financial, personal, and professional impacts, the accumulated exposure to natural disasters can negatively impact working conditions and cause burnout and psychological distress for workers in this sector.

In a different but related vein, participants shared their experiences as emergency responders on the ground in the spring 2017 floods. They reported a lack of preparation of and support for some workers—including frontline workers, first responders, and volunteers—for responding to victims' psychological needs and coping with the situations they encountered. These participants added that such problems increased the psychological effects workers experienced, such as negative emotions. These participants also mentioned that the process of relocating evacuated victims could take as long as several months, requiring the involvement of psychosocial care professionals and healthcare network teams over long periods. These circumstances created work overload due to exceeded capacities, leading to significant physical and psychological fatigue for workers along with feelings of powerlessness over long wait times for victims.

The participants also stated the importance of considering the characteristics of the flood (sudden vs. gradual, intensity, duration, losses incurred, etc.), the type of setting, the time of the year, and the population affected when assessing the psychosocial effects on workers. These characteristics can alter the occurrence and extent of these effects. During the spring 2017 floods in Québec, the realities of urban environments (metropolitan areas and large agglomerations) differed greatly from rural environments (small municipalities) with respect to the organization and availability of services and resources. In small municipalities, the lack of resources needed to provide certain services (reduced response teams, difficulty mobilizing staff, absenteeism) created work overload, causing workers fatigue. Finally, participants also mentioned that the psychosocial effects of such events are not exclusively negative. Field workers (blue-collar and other frontline workers) expressed feelings of pride in their involvement in managing the disaster. They added that receiving recognition from the public and bonding with victims contributed to their appreciation of their work.

5.1.3 Heat waves

To our knowledge, no studies on the psychosocial effects of heat waves on workers in a comparable socioeconomic context to Québec's have been published to date. In order to establish whether other types of literature have documented this topic, the results of the literature search were reassessed to select literature reviews on the psychological effects and social impacts of heat on workers (including organizational factors). Two literature reviews were selected for the knowledge they contributed to the synthesis.

A literature review (Xiang et al., 2014) of studies published between 1997 and 2012 (52 quantitative and three qualitative studies) on the health impacts of exposure to heat at work revealed that the psychosocial effects of heat exposure have been little studied. The psychosocial effects of heat exposure have, however, been addressed to some extent from a workers' health and safety risk prevention perspective. Exposure to heat and its impacts on cognitive performance were mentioned in this review (e.g., slowed reaction time, reduced alertness, increased risk of errors and omissions), along with the effects of heat acclimatization on these processes, as these factors can affect workers' safety in their work settings.

The second literature review (Kjellstrom et al., 2016) focused specifically on decreased performance and working capacity in high outdoor temperatures. The authors mentioned that this reduced performance and work capacity will have social impacts and cause significant economic losses that will be exacerbated by the projected temperature increases of CC.

These literature reviews nonetheless underscored that the risks associated with exposure to excessive heat at the workplace vary by sector of activity. The workers most likely to be exposed to such risks are those who perform tasks outdoors and who must physically exert themselves. Examples include people working on farms and in construction, mines, transportation, fire

services (firefighters), and the armed forces. At-risk workers also include people who work indoors (and are therefore not directly exposed to solar radiation), but who may be subject to the heat and humidity generated by work processes and equipment. These environments can reach very high temperatures when their cooling or ventilation systems are insufficient.

Experiences specific to workers in Québec

On several occasions, laboratories of ideas participants mentioned the physical effects workers experience during heat waves. Some psychological effects were also mentioned, such as irritability and feelings of helplessness caused by involuntary exposure to higher temperatures during their professional activities.

One Québec-specific example mentioned by a participant concerned healthcare network employees who have to deal with the increased needs of their clientele and a higher workload during heat waves. In these situations, heat can become a source of additional discomfort, leading to physical and psychological fatigue. Employees in the kitchens of long-term care facilities were also identified as workers who are vulnerable to heat waves as they work in very hot environments that can harm their well-being, which is already affected by the heat outdoors.

Agriculture was also named as a sector vulnerable to heat waves, and more broadly, the impacts of CC on summer seasons. The extended hot season, influenced by CC, affects work organization. Though agricultural activities are peaking at increasingly early periods (e.g., the early vegetable harvest in late summer 2017) and continue past the usual period, the availability of seasonal workers remains the same (i.e., from around late June to early September). This can create staffing problems, in turn causing atypical schedules, accelerated production rates, and work overload leading to fatigue for the regular labour force. These conditions can also result in reduced worker productivity and repercussions on the employer's financial situation.

Laboratories of ideas participants wanted to broaden the discussion on the psychosocial effects of heat and emphasized the gaps in prevention in Québec. For example, they raised the matter of small organizations being less prepared to cope with periods of extreme heat as they have fewer dedicated occupational health and safety resources than larger companies. They added that some Québec employers underestimate the problems extreme heat pose, despite efforts to raise awareness. The major problems experienced on the construction site at the Centre hospitalier de l'Université de Montréal (CHUM) in July 2016 were mentioned. A strike took place on the construction site and around 2,600 workers left their posts as these difficult working conditions had caused numerous bouts of illness, some of which required emergency room visits and hospitalization.

5.1.4 Forest fires

Synthesis of knowledge from the scientific literature

Two studies on the psychological impacts of forest fires on workers were identified in the literature search (Cherry and Haynes, 2017; Doley, Bell, and Watt, 2016). These studies documented the psychosocial effects occurring between three months and seven years following the events.

Description of the scale of the events documented

The forest fires addressed in the literature were high-intensity natural disasters, the tolls of which included the following: many displaced, injured, or otherwise affected people; deaths; and significant damage and material losses. These studies documented various psychosocial effects on workers exposed to these fires and their aftereffects.

Psychosocial effects and associated factors among workers in the Fort McMurray region

Authors Cherry and Haynes (2017) studied the psychological health of various paid employees (such as those in the welding and electricity industries) during the violent wildfires that ripped through the Fort McMurray area in Alberta, Canada, on May 3, 2016. The study brought to light specific difficulties workers had to cope with. Of the 130 workers who participated in the study, the majority were present on May 3, 2016 ($n = 109$), when the evacuation order was given. Of these 130, 103 workers were evacuated and relocated. Of the 109 workers present at the time of the fire, 15 (nearly 14%) reported experiencing psychological health problems “caused or aggravated by the fire.” The study found that workers who were evacuated from Fort McMurray experienced greater anxiety and depression than those who were not evacuated. Contrary to the authors’ expectations, no significant increase in the consumption of recreational drugs, the consumption doctor-prescribed medications, or alcohol or tobacco use was observed among the workers following the fire.

Psychosocial effects and associated factors among Australian volunteer firefighters

Doley et al.’s study (2016) showed that volunteer firefighters’ exposure to the high-intensity bushfires of 1983 in Australia had long-term effects on their psychological health. It bears mentioning that a series of studies published between 1985 and 1989 assessed the impact of these fires on the psychological health of a cohort of volunteer firefighters involved in controlling and extinguishing them. Doley et al. (2016) continued these studies by documenting the psychological effects on 277 firefighters 84 months (7 years) after the fires. The results indicated that nearly 28% of these firefighters ($n = 75$) reported experiencing symptoms of depression, anxiety, insomnia, or a lower level of functioning after this 84-month period. However, exposure to the fires of 1983 on its own is not a sufficient explanation for the observed results and the authors have suggested that other factors, like recent exposure to negative events, could have had a significant impact on their psychological health.

This study also revealed that 45 firefighters who presented symptoms of PTSD 42 months after the fires were no longer suffering from a mental health disorder 84 months after the fires. As the authors stress, it cannot be concluded from this finding alone that these workers' psychological health had been restored, as the symptoms of PTSD could vary according to the situations the workers had faced.

Experiences specific to workers in Québec

No participants in the laboratories of ideas were specifically involved in forest fire management in Québec. They nonetheless mentioned that workers exposed to a forest fire may experience a hasty evacuation as a traumatic event because they may perceive the situation as a threat to their physical safety or life. As supported by the literature, participants emphasized that forest fires can cause significant economic losses for communities economically dependent on the forest or that are located in the affected region. The presence of such fires can result in production slowdowns or stoppages in a given industry (commercial, industrial, tourism, etc.) and contribute to job losses.

Other relevant information on the psychosocial effects of EWEs in Québec

Laboratories of ideas participants discussed two aspects related to all EWEs, regardless of their nature, that merit mention. First, damaged infrastructure following an EWE can affect the occurrence and severity of psychosocial effects on workers as it may alter their environment and work conditions. The media coverage of events can also influence the occurrence of psychosocial effects experienced by workers, providing some with public recognition of the disaster and the recovery efforts of various actors. Moreover, media coverage of an EWE lessens feelings of abandonment or anger experienced by the victims with whom workers must interact.

5.2 Integrative diagram of the knowledge

The results of the scientific publications and laboratories of ideas discussions have been summarized in an integrative diagram. This diagram illustrates the psychosocial effects experienced by workers exposed to the EWEs studied (see Figure 2).

It is worth noting that stress is a central concept in this diagram. Stress is a bodily reaction to an event that triggers a physical, psychological, and emotional coping response for an individual (Lazarus, 1993). The individual's response to a stressful event depends on their interpretation of the event. The individual will experience a negative stress reaction that can have psychosocial effects if they perceive the event as a threat³ (see Lazarus, 1993). It should be kept in mind that an EWE is likely to produce a stress reaction in workers in the context of this study, and that it is an event taking place in their physical environment.

³ In the scientific studies reviewed, the threat factor of each EWE as perceived by the worker was not directly documented. That said, from the nature of the psychosocial effects reported by the workers themselves in these studies, one can infer that a good number perceived a level of threat associated with the EWE.

In Figure 2, it can be observed that workers' stress responses to EWEs take different forms over time and depend on moderating and buffering factors and events indirectly caused by the EWE. Firstly, factors preceding the EWE and specific to each worker, i.e., moderating factors, can modulate the intensity of the stress experienced by the worker. These factors include: 1) their job type, 2) their previous emergency response and victim assistance training, 3) their number of years of experience in their position,⁴ 4) their age, 5) their gender,⁵ 6) their personal history of trauma,⁶ and, 7) their personality traits, including optimism (see Box 1). Moreover, events indirectly caused by the EWE may also influence the nature and intensity of the stress response, including the occurrence of psychosocial effects. A given EWE leaves a cascade of events in its wake, and the worker may have to cope with these in their personal life and/or in performing their duties. The worker's experience with these events (or lack thereof) factors into the stress response to the EWE. A worker may be confronted with a number of such events directly related to the EWE; examples include the death of a close relative, destruction of their home, loss of their job, body recovery, evacuation and relocation to a shelter, repeated exposure to victims' stories, etc. (see Box 2). Buffering factors also influence the link between the EWE and the stress response, including the psychosocial effects experienced by the worker. The social support received by the worker, the coping strategies⁷ adopted by the worker, and the collective efficacy of the community affected by the EWE influence the nature and intensity of the psychosocial effects observed in the worker (see Box 3).

In terms of psychopathology (see Box 4), the worker may experience acute stress disorder⁸ in the days and weeks following the EWE. Beyond a period of around one month, and if the worker's personal resources to cope with stress are insufficient or inadequate, the worker may develop one or more of the following mental disorders (in comorbidity)⁹: 1) PTSD, 2) depression, 3) substance abuse.¹⁰ Furthermore, some studies have documented cognitive reconstruction in a significant group of workers.¹¹ The cognitive reconstruction process becomes consolidated three

⁴ An experienced worker will be better equipped to deal with emergency situations caused by the EWE.

⁵ Some of the studies reviewed suggest that female workers present more clinical manifestations of stress in response to an EWE than male workers.

⁶ According to the studies examined, workers with a history of trauma present more significant psychosocial effects.

⁷ Coping strategies are defined as the individual's biological, behavioural, and cognitive efforts to deal with the stressful event.

⁸ Acute stress disorder is a set of symptoms that can develop in response to exposure to one or more traumatic events. It generally involves a significant anxiety response that includes some form of reliving the traumatic event. According to the criteria of the DSM-5, acute stress disorder is diagnosed three days to one month following exposure to one or more traumatic events. A PTSD diagnosis is considered after one month.

⁹ Post-traumatic stress disorder is often found in comorbidity with depression.

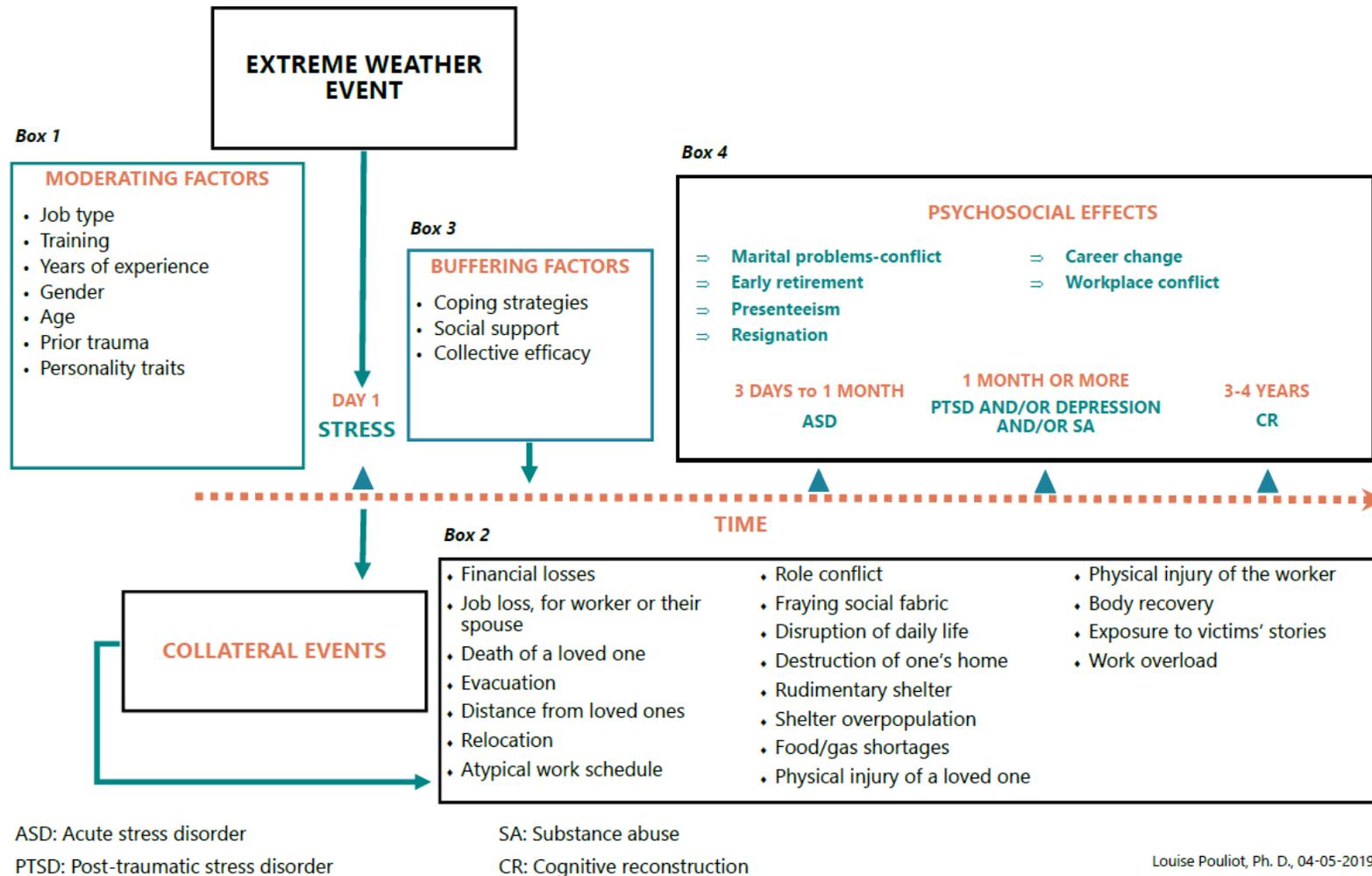
¹⁰ Alcohol and/or drugs.

¹¹ Among some workers, the EWE and its aftermath provoke a significant upheaval in their beliefs and existential bearings. The cognitive reconstruction process consists of the worker giving new meaning to their life and to the EWE.

to four years after the EWE. Psychosocially (see Box 4), the studies show a number of effects of EWEs on workers, including marital problems and conflict at work.

In sum, as demonstrated by the following diagram, the psychosocial effects of EWEs on workers can occur in the short and long term and result from a complex process and various personal and environmental factors.

Figure 2 Integration of the data from studies and discussions with key actors on the psychosocial effects experienced by workers due to various extreme weather events according to transactional models (Lazarus, 1999), the diathesis-stress model (Sigelman and Rider, 2009), the psychosocial model (Brown, 1997), the biopsychosocial model (Benquin, 2010), and elements borrowed from the clinical research (American Psychiatric Association, 2013).



5.3 Priority avenues for research and intervention

As previously mentioned, the knowledge synthesis was presented to different key actors during the laboratories of ideass and these actors were invited to propose avenues for research and intervention. In total, 21 avenues were proposed. Among these avenues, six are related to heat waves, two to storms, and seven to flooding, while six were proposed for EWEs in general. No avenues were suggested for forest fires, even though the laboratories of ideass were queried on the topic.

The vast majority of avenues for research and intervention agreed upon in the laboratories of ideass concerned describing and understanding the psychosocial effects experienced by exposed workers; only six of the 21 avenues focused specifically on implementing adaptive measures. Some groups of workers were identified as more vulnerable to EWEs, such as frontline workers (including professionals in the healthcare network and social services, and municipal employees such as blue-collar workers), farmers, and workers in the construction sector. Most avenues, however, did not define a specific group of workers to study.

Following the laboratories of ideass, a prioritization exercise was conducted with the members of the monitoring committee to rank the avenues by their importance for Québec. Table 1 presents the priority order of the 21 avenues with their overall scores. As a reminder, the avenue rated to have the highest priority by the group is the one with the lowest overall score while the one rated with the lowest priority has the highest overall score. The avenues related to flooding were the highest rated by the monitoring committee. In addition, two groups of workers, frontline workers and farmers, were more frequently mentioned in the highest rated avenues.

Table 1 Avenues for research or intervention proposed by laboratories of ideas participants and overall scores by the monitoring committee

Avenues for research or intervention	Targeted events	Targeted sectors	Overall score
Verify whether the Québec Public Health Survey contains indicators related to psychological distress in workers and propose their inclusion if missing.	All events	Unspecified	19
Develop tools to compensate for the lack of information (and lack of information distribution) for frontline workers on the health risks of exposure to floodwater.	Flooding	Frontline workers	23
Document the psychosocial effects on one or more working populations (e.g., front-line workers) following flooding in different health regions and identify protective factors.	Flooding	Unspecified	23
Document examples of psychosocial effects experienced by workers following other disasters in Québec to compare with the EWEs studied.	All events	Unspecified	23
Conduct a survey in order to study the psychological effects of heat on workers as this topic has not been covered in the scientific literature.	Heat	Unspecified	24
Add a component on workers' psychological health to a public health survey to be conducted in Québec to document the health status and vulnerability of populations affected by the flooding in spring 2017.	Flooding	Unspecified	24
Apply the recommendations of the INSPQ's <i>Boîte à outils pour la surveillance épidémiologique lors d'un sinistre : surveillance à moyen et à long terme des impacts sur la santé mentale</i> during one or more EWEs to document how they impact workers.	All events	Unspecified	24
Identify the farmers who incurred crop losses and financial losses as the result of storms and question them on the psychosocial effects they experienced. Agriculture financial service providers were suggested as a means to identify these workers.	Storms	Farmers	25
Describe the state of knowledge on a specific flooding event to obtain information such as the type of workers affected, the observed symptoms and their progression, and workers' adaptiveness and resiliency, while applying the recommendations in the INSPQ's <i>Boîte à outils pour la surveillance épidémiologique lors d'un sinistre: surveillance à moyen et à long terme des impacts sur la santé mentale</i> .	Flooding	Unspecified	26
Conduct research to document the psychosocial effects on workers of multiple EWEs to identify trends.	All events	Unspecified	26
Document the occupational health and safety interventions and the content of the inspector's reports from the CHUM construction site closure in July 2017.	Heat	Construction workers	28

Table 1 Avenues for research or intervention proposed by the laboratories of ideas participants and overall ratings by the monitoring committee (cont'd)

Avenues for research or intervention	Targeted events	Targeted sectors	Overall score
Compile data to establish a link between heat and absenteeism at the workplace in healthcare network and social services settings.	Heat	Healthcare network and social services workers	29
Develop methods of popularizing existing tools that present preventative measures to implement in workplaces during hot weather, especially for the construction and agriculture sectors.	Heat	Construction and agricultural workers	29
Conduct a longitudinal study on groups of workers following a flood (monitoring a population over time with an event as a starting point) to document its psychosocial effects.	Flooding	Unspecified	30
Explore methods of strengthening flood prevention through land-use planning by, for example, implementing regulations and permits in flood-prone areas.	Flooding	Unspecified	31
Develop ways of fostering awareness in the construction sector and informing managers and employees of the health risks of excessive exposure to heat to ensure the issue receives the same recognition as the health risks of exposure to cold.	Heat	Construction workers	31
Develop ways of fostering awareness in work environments and informing managers and employees of the health risks related to excessive exposure to heat to better integrate the issue into management activities and ultimately in work agreements and contracts.	Heat	Unspecified	32
Conduct case studies on floods in Québec in the last 20 to 30 years to identify trends in terms of the number of workers affected, the job types and sectors to target, the nature of the damage according to the gravity and severity of the events, etc.	Flooding	Unspecified	33
Explore mechanisms to promote solidarity and mutual aid and minimize the tension and irritability that civilians direct at workers (e.g., blue-collar workers) during storms.	Storms	Unspecified, but blue-collar workers are cited as an example	37
Document the consequences of EWEs in the rest of the world in terms of response, workers' reactions, and the psychosocial effects experienced.	All events	Unspecified	38
Conduct retrospective evaluations on groups of workers after an EWE to document its psychosocial effects.	All events	Unspecified	33–41*

* One of the participants gave a rating of 4–12 for one of the four criteria of this avenue for research. The total of the ratings for this avenue's four criteria therefore ranges from 33 to 41.

6 DISCUSSION

This preliminary study made it possible to detail the state of knowledge of the negative psychosocial effects experienced by workers as the result of four EWEs that will be exacerbated in Québec by CC. These EWEs are flooding, heat waves, storms, and forest fires. It also made it possible to propose avenues for research and intervention that respond to workplace and public health needs and that will ultimately help better protect workers in Québec.

6.1 Knowledge synthesis and integrative diagram

6.1.1 Highlights

The knowledge synthesis was written taking into account the content of the publications identified in the literature search (30 original studies and two literature reviews), supplemented by the experiences and knowledge shared by the laboratories of ideas participants. This synthesis reveals a number of findings.

First, the EWEs studied can cause psychosocial effects among workers, but the knowledge of these effects varies greatly by EWE. The psychosocial effects on workers were most thoroughly observed and reported in the scientific literature for storms, less well documented for floods and forest fires, and scarcely documented for heat waves (Appendix 4). The consultation process with key actors made it possible to fill in part of the picture. It is nonetheless evident that new knowledge must be developed in this area, particularly in relation to heat waves, as we were unable to identify any original studies on this topic using our literature review strategy. Though this topic has been little studied, that does not necessarily mean that heat waves have no psychosocial effects, but rather suggests that this is a new topic that the research has still little addressed. Additionally, studies show a link between the increase in outdoor temperatures and interpersonal conflict and violence. Assaults have been observed during uncomfortably hot periods between players during sports events, in reports describing domestic violence, and by police officers during training exercises, for example (Applebaum et al., 2016).

Second, the knowledge on the types of workers who have experienced psychosocial effects varies. Frontline workers like municipal employees (police officers, firefighters, health professionals who work with emergency victims, public works employees, etc.) and farmers are among the working populations most studied in the literature (Appendix 4). This is consistent with the fact that these workers are 1) directly exposed to EWEs as their work requires that they be directly involved in activities responding to the event (particularly frontline workers), 2) directly impacted by EWEs, as the resources on which their livelihoods rely may be affected by these events (particularly farmers).

Third, this knowledge synthesis also revealed that negative psychological effects have been more extensively documented than negative social impacts. Burnout, fatigue, psychological distress, anxiety, anger, and sadness were all identified in workers who had been exposed to EWEs. These effects, although measured differently and reported using varying terms, did not greatly differ between EWEs. Social impacts, however, received little attention in the scientific literature and in our laboratories of ideas discussions with key actors. In concrete terms, conflicts between family members, colleagues, and organizations were documented in the literature as impacts resulting from storms. In addition, conflicts between civilians and workers due to storms were mentioned by the laboratories of ideas participants. The social impacts of EWEs merit further study in future work to see whether such issues are present in workplaces.

Fourth, the importance of certain risk factors that aggravated the psychosocial effects experienced by workers, and which are common to multiple EWEs and numerous types of workers, were identified in the literature and in the laboratories of ideas discussions. Documented risk factors related to work included the following: work overload; a lack of training, material resources, and available staff; working in uncomfortable conditions; and a lack of organizational support (Fullerton et al., 2013; Tak et al., 2007; Yarbrough et al., 2007; West et al., 2014). Other personal risk factors, such as being a disaster victim, lack of contact with family, injured family members, and personal loss, were also identified (West et al., 2014). Together these organizational and personal factors were primarily reported after storms and flooding for frontline workers, predominantly first responders, police officers, and psychosocial care professionals. On the other hand, some protective factors were also identified through the knowledge synthesis, particularly after storms. Factors related to well-being (e.g., appreciation or gratitude, individual resilience, etc.), social support, and collective efficacy can help mitigate the negative repercussions of hurricanes in first responders (McCanlies et al., 2014; Leppma et al., 2017; Adams and Turner, 2014; Raveis et al., 2017; Fullerton et al., 2015). Other organizational and experiential factors also had a protective effect on some psychosocial care professionals, such as having received training on working with disaster victims, prior field experience, working with experienced volunteers, debriefing sessions at the end of the workday, having well-defined work hours, implementing self-care strategies, and more (Dass-Brailsford and Thomley 2010; Clukey, 2010; Lambert and Lawson, 2013; Leppma et al., 2017).

Fifth, this synthesis emphasized the importance of supplementing the literature review content with the experiences of various key actors. This step also made it possible to identify new types of vulnerable workers that had not been identified in the literature review. For example, electrical power line workers and municipal workers were identified as vulnerable following storms, and workers in the construction, agriculture, healthcare, and small business sectors were identified as vulnerable in a heat wave. This step also made it possible to learn more about aspects of the events that can influence the occurrence of psychosocial effects in workers, such as the inherent characteristics of such EWEs: onset (sudden vs. gradual), intensity, duration, losses incurred,

settings affected (urban vs. rural), etc. It also clarified that the psychosocial effects experienced due to an EWE were not exclusively negative, as on-the-ground responders mentioned feeling greatly appreciated by victims and pride in having played a role in managing the crisis. This is an important aspect that would be worthwhile to take into consideration in future work to identify aspects that could promote the well-being of workers exposed to EWEs.

6.1.2 Methodological limitations

Knowledge synthesis

The knowledge synthesis has certain methodological limitations. The literature search strategy considered criteria related to the type of publication and its relevance; the scientific quality of the studies was not assessed, although the selected articles were all peer reviewed. Most of the authors of the quantitative studies consulted noted methodological limitations and possible biases in their research. For example, the scientific knowledge collected here is mainly based on observational studies (cross-sectional, longitudinal, before and after). Such studies offer low-quality evidence and a causal link cannot generally be inferred between the observed associations. Moreover, it may not have been possible for studies with small sample sizes to demonstrate certain psychosocial effects, given their low statistical power. It is also possible that the onset of psychological symptoms preceded exposure to the EWE in certain studies, as the data collection methods used and the temporal sequence between exposure and the onset of symptoms were not always easy to verify. For example, in the studies on at-risk and stressful occupations, such as police work—police officers are at a high risk of exposure to traumatic events—it is possible that the reported symptoms or disorders were present before the EWE (West et al., 2008). Furthermore, factors limiting the representativeness of the populations studied were identified, such as small sample sizes (e.g., Battles and Slidell, 2007; Dass-Brailsford and Thomley, 2012), low survey response rates,¹² convenience sampling (e.g., Dass-Brailsford and Thomley, 2012) and volunteer bias in samples made up of volunteers (e.g., Raveis et al., 2017),¹³ and, to a lesser extent, insufficient description of the sample studied (e.g., Cherry and Haynes, 2017).

Consultations with key actors

For the laboratories of ideas consultations with key actors, it is important to emphasize that the choice of participants may have influenced the discussions and in turn, the content of the knowledge synthesis. Key actors were selected in collaboration with the monitoring committee and efforts were made to ensure varied expertise and participants who could shed light on the realities of vulnerable groups of workers. These efforts also made it possible to have laboratories

¹² It is worth mentioning that the profile of non-respondents is generally not provided, making it difficult to know if certain groups of the studied population are over- or under-represented.

¹³ Samples made up of volunteers: the respondents may have specific traits, i.e., those who have suffered severe psychological trauma may have been less inclined to participate.

of ideas groups made up of workers experienced in the field, workplace health and safety consultants, public health network professionals, and university professors. However, key participants familiar with the context of forestry workers had to miss the laboratories of ideas. Their presence would have undoubtedly improved the information related to the impacts of forest fires in the knowledge synthesis.

Integrative diagram

As a complement to the previous steps, a theoretical construct has been proposed in the form of an integrative diagram of the data collected from the selected publications. This diagram was created from an analysis of the content. The various stages of the content analysis were conducted by a single analyst. It is therefore possible that the analyst's subjectivity influenced the theorization of these effects. Moreover, it is difficult to discuss the accuracy of the textual data coding process as only one person performed this task. Biases and/or errors may have crept into the process without it being possible to check for them. Nonetheless, despite its limitations, the diagram offers a heuristic opportunity that merits validation and the addition of further data.

6.2 Avenues for research and intervention

Consultation with key actors allowed for 21 avenues for research and intervention to be identified for Québec, which were then prioritized by the monitoring committee. Some observations follow on the avenues proposed and their prioritization.

First, the vast majority of the avenues proposed by participants aimed to acquire new knowledge on the psychosocial effects experienced by workers exposed to EWEs. This suggests that the topic of psychosocial effects in workers exposed to EWEs is still new and that the public health and occupational health networks need to develop their knowledge before proposing adaptation measures to protect workers. Second, flooding is the event for which the most avenues for research or intervention were proposed and prioritized. The fact that flooding was prioritized above other EWEs may be explained by Québec's particular environmental context in spring 2017, a few months before this study. There was major flooding from February to June 2017, in 15 administrative regions of Québec. The Greater Montréal area and the regions of Outaouais, Montérégie, Mauricie, Lanaudière, and the Laurentians were most severely affected (Croix-Rouge Canadienne, 2019). In total, 291 municipalities were affected by this event, during which 22 municipalities and an agglomeration declared a state of emergency. This major event required the support of the Canadian Armed Forces for nearly a month. In total, 5,371 primary residences were flooded, 4,066 people were evacuated, and nearly 400 roads were damaged. This major event is now a part of Québec's popular imagination and has left a mark on its communities.

For this reason, fewer avenues for research or intervention were specifically proposed for the other EWEs. Six avenues were nonetheless proposed for the impacts of heat waves (versus seven for flooding), which is a reminder of the significant gaps in the knowledge about this topic. However, these avenues were generally not rated very highly by the monitoring committee. Two avenues that were not considered priorities by the monitoring committee addressed the impacts of storms. One of these avenues targeted the psychological effects of agricultural and financial losses incurred by farmers as the result of storms, and the other addressed mechanisms to implement to minimize tensions between civilians and municipal workers during storms. No avenues in relation to forest fires were proposed, even though the laboratories of ideass were queried on this topic. This may be explained by the absence of participants from this sector at the laboratories of ideass and the participants' lack of experience with this type of event.

Finally, the prioritization exercise performed by the members of the monitoring committee highlighted that flooding was the priority EWE for Québec. Frontline workers and farmers were also identified as the priority working populations. The study of psychosocial effects experienced by frontline workers due to flooding is consistent with the Québec news published in the months following the completion of this study. It was reported that around 40 cases of PTSD were diagnosed in City of Montréal municipal employees who had participated in the efforts to minimize the impacts of the 2017 floods. The long work hours in difficult conditions and distress experienced by victims were provided as some of the underlying explanations for the situation (Normandin, 2018; Ville de Montréal, 2017). Moreover, flooding is the most common type of natural disaster in Québec, and it is clearly projected that exceptional spring thaws like those that occurred in 2017 will reoccur in the future (Ouranos, 2019).

7 CONCLUSION

In conclusion, this project proposed conducting a preliminary study to summarize the knowledge on the negative psychosocial effects of heat waves, flooding, forest fires, and storms on workers in Québec. This study also aimed to propose new research and intervention projects that respond to Québec's workplace and public health needs. Over the course of this project, a knowledge synthesis and integrative diagram of the current knowledge were developed and 21 avenues for research or intervention were proposed and ordered by priority. This project has underscored that developing knowledge on the psychosocial effects experienced by workers due to flooding is a topic of interest for Québec.

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APPENDIX 1 NAMES AND AFFILIATIONS OF MONITORING COMMITTEE MEMBERS

Names and affiliations of monitoring committee members

Campagna, Céline (INSPQ): Scientific Lead, health component of the Government of Québec's 2013-2020 Climate Change Action Plan

Laplante, Lise (INSPQ): Specialist Physician, responsible for the scientific team for environmental health, assessment and risk management support

Ménard, Marie (Québec Union des producteurs agricoles): Coordinator, occupational health and safety department

Perron, Stéphane (INSPQ): Specialist Physician, Direction de la santé environnementale et de la toxicologie

Torres, Monica (public health department of the Centre intégré de santé et de services sociaux des Laurentides): Specialist Ergonomist

Vézina Michel (INSPQ): Medical Specialist, Occupational Health

APPENDIX 2 LITERATURE SEARCH STRATEGY

Database search algorithms

OID PLATFORM

Two databases on the Ovid platform were consulted:

1. Embase
2. Ovid MEDLINE

Table 2 Queries and results in Embase and Ovid MEDLINE databases

	Concept 1 – Negative psychological effects and social impacts	Embase	MEDLINE
1	(mental* OR psych* OR emotion* OR mood* OR wellbeing OR (well ADJ being) OR wellness).ti,ab,kw.	1,430,589	1,170,503
2	(stress* OR anxiet* OR insecur* OR panic OR worr* OR depress* OR despair* OR distress* OR grief OR griev* OR powerless* OR irritab* OR aggressi* OR anger* OR rage* OR (post ADJ traumatic) OR PTSD OR trauma* OR burnout* OR burn-out* OR fatigue OR tiredness OR suicid* OR ((alcohol* OR tobacco OR drug* OR substance* OR medication*) ADJ5 (abus* OR misuse* OR addiction* OR dependanc*)) OR (self ADJ (harm* OR injur*))).ti,ab,kw.	2,445,236	1,942,392
3	1 ADJ10 2	300,279	228,610
4	(social OR sociopsycho* OR (socio ADJ psycho*)).ti,ab,kw.	526,308	439,179
5	(violence OR conflict* OR strike* OR (protest* ADJ2 movement*)).ti,ab,kw.	182,251	157,540
6	((((los# OR reduction OR reduced OR decreas*) ADJ3 (productivity OR motivation OR satisfaction OR performance OR wage* OR income*)) OR absenteeism OR presenteeism OR turnover).ti,ab,kw.	139,406	121,461
7	((los# OR miss*) ADJ3 (job* OR employment OR work)).ti,ab,kw.	8,348	6,082
8	4 OR 5 OR 6 OR 7	826,407	700,260
9	3 OR 8	1,060,366	880,030
	Concept 2 – Extreme weather events including heat waves, flooding, storms, and forest fires		
10	(disaster* OR (natural ADJ3 hazard*) OR (extrême* ADJ3 (weather OR climat*)) OR (climate ADJ change)).ti,ab,kw.	48,537	44,260
11	(heatwave* OR (heat ADJ wave*) OR (hot ADJ temperature*) OR (extreme ADJ heat)).ti,ab,kw.	2,403	2,218
12	(flood* OR inundation* OR flashflood*).ti,ab,kw.	15,786	14,071
13	(storm* OR precipitation* OR rain OR rainstorm* OR rainfall* OR downfall* OR downpour*).ti,ab,kw.	104,488	86,867
14	(snowstorm* OR (snow ADJ2 storm*) OR snowfall* OR (snow ADJ2 fall*) OR blizzard*).ti,ab,kw.	923	755
15	(thunderstorm* OR (thunder ADJ storm*) OR lightning).ti,ab,kw.	1,956	1,976
16	(wind OR windstorm* OR (wind ADJ2 storm*) OR tornado* OR twister* OR hurricane* OR cyclone*).ti,ab,kw.	24,157	19,163
17	((forest* ADJ fire*) OR wildfire* OR (wild ADJ fire*) OR bushfire* OR (bush ADJ fire*)).ti,ab,kw.	2,634	2,367
18	10 OR 11 OR 12 OR 13 OR 14 OR 15 OR 16 OR 17	185,861	158,478

Concept 3 – Workers and workplaces			
19	(occupational OR worker* OR workplace* OR working OR personnel OR professional* OR employee* OR job? OR labo?r OR volunteer*).ti,ab,kw.	1,247,003	1,044,123
Concepts 1, 2, and 3 combined			
20	9 AND 18 AND 19	1,796	1,489
Language limit			
21	..l/20 lg=English OR lg=French	1,688	1,405
Date range			
22	limit 21 to yr="2007 -Current"	1,179	956
Exclusion of letters, comments, editorials			
23	22 NOT (letter or comment or editorial),pt	1,169	949
Removal of duplicates			
24	..dedup 23	1,116	888

EBSCO PLATFORM

Four databases on the EBSCO platform were consulted:

1. Environment Complete (EC)
2. Psychology and Behavioral Sciences Collection (PBSC)
3. PsycInfo (Psycl)
4. SocINDEX with Full Text (Socl)

Table 3 Queries and results in EBSCO databases

Concept 1 – Negative psychological effects and social impacts		EC	PBSC	Psycl	Socl
S1	TI(mental* OR psych* OR emotion* OR mood* OR wellbeing OR (well W0 being) OR wellness) OR AB(mental* OR psych* OR emotion* OR mood* OR wellbeing OR (well W0 being) OR wellness) OR SU(mental* OR psych* OR emotion* OR mood* OR wellbeing OR (well W0 being) OR wellness)	56,295	318,400	1,924,955	419,830
S2	TI(stress* OR anxiet* OR insecur* OR panic OR worr* OR depress* OR despair* OR distress* OR grief OR griev* OR powerless* OR irritab* OR aggressi* OR anger* OR rage* OR (post W0 traumatic) OR PTSD OR trauma* OR burnout* OR burn-out* OR fatigue OR tiredness OR suicid* OR ((alcohol* OR tobacco OR drug* OR substance* OR medication*) N5 (abus* OR misuse* OR addiction* OR dependanc*)) OR (self W0 (harm* OR injur*)) OR AB(stress* OR anxiet* OR insecur* OR panic OR worr* OR depress* OR despair* OR distress* OR grief OR griev* OR powerless* OR irritab* OR aggressi* OR anger* OR rage* OR (post W0 traumatic) OR PTSD OR trauma* OR burnout* OR burn-out* OR fatigue OR tiredness OR suicid* OR ((alcohol* OR tobacco OR drug* OR substance* OR medication*) N5 (abus* OR misuse* OR addiction* OR dependanc*)) OR (self W0 (harm* OR injur*)) OR SU(stress* OR anxiet* OR insecur* OR panic OR worr* OR depress* OR despair* OR distress* OR grief OR griev* OR powerless* OR irritab* OR aggressi* OR anger* OR rage* OR (post W0 traumatic) OR PTSD OR trauma* OR burnout* OR burn-out* OR fatigue OR tiredness OR suicid* OR ((alcohol* OR tobacco OR drug* OR substance* OR medication*) N5 (abus* OR misuse* OR addiction* OR dependanc*)) OR (self W0 (harm* OR injur*))	167,490	142,152	912,351	214,724
S3	S1 N10 S2	7,559	62,045	313,189	57,762
S4	TI(social OR sociopsych* OR (socio ADJ psycho*)) OR AB(social OR sociopsych* OR (socio ADJ psycho*)) OR SU(social OR sociopsych* OR (socio ADJ psycho*))	94,209	132,465	842,016	683,117
S5	TI((violence OR conflict* OR strike* OR (protest* N2 movement*)) OR AB((violence OR conflict* OR strike* OR (protest* N2 movement*)) OR SU((violence OR conflict* OR strike* OR (protest* N2 movement*))	34,050	29,683	194,331	165,892
S6	TI(((los# OR reduction OR reduced OR decreas*) N3 (productivity OR motivation OR satisfaction OR performance	20,423	3,919	29,469	9,390

	OR wage* OR income*)) OR absenteeism OR presenteeism OR turnover) OR AB(((los# OR reduction OR reduced OR decreas*) N3 (productivity OR motivation OR satisfaction OR performance OR wage* OR income*)) OR absenteeism OR presenteeism OR turnover) OR SU(((los# OR reduction OR reduced OR decreas*) N3 (productivity OR motivation OR satisfaction OR performance OR wage* OR income*)) OR absenteeism OR presenteeism OR turnover)				
S7	TI((los? OR miss*) N3 (job* OR employment OR work)) OR AB((los? OR miss*) N3 (job* OR employment OR work)) OR SU((los? OR miss*) N3 (job* OR employment OR work))	1,093	699	3,747	2,760
S8	S4 OR S5 OR S6 OR S7	143,305	157,350	1,000,643	798,935
S9	S3 OR S8	149,067	201,936	1,218,042	830,302
Concept 2 – Extreme weather events including heat waves, flooding, storms, and forest fires					
S10	TI(disaster* OR (natural N3 hazard*) OR (extreme* N3 (weather OR climat*)) OR (climate W0 change)) OR AB(disaster* OR (natural N3 hazard*) OR (extreme* N3 (weather OR climat*)) OR (climate W0 change)) OR SU(disaster* OR (natural N3 hazard*) OR (extrême* N3 (weather OR climat*)) OR (climate W0 change))	117,595	7,537	15,119	12,537
S11	TI(heatwave* OR (heat W0 wave*) OR (hot W0 temperature*) OR (extreme W0 heat)) OR AB(heatwave* OR (heat W0 wave*) OR (hot W0 temperature*) OR (extreme W0 heat)) OR SU(heatwave* OR (heat W0 wave*) OR (hot W0 temperature*) OR (extreme W0 heat))	2,002	111	2,855	143
S12	TI(flood* OR inundation* OR flashflood*) OR AB(flood* OR inundation* OR flashflood*) OR SU(flood* OR inundation* OR flashflood*)	44,099	995	2,447	2,290
S13	TI(storm* OR precipitation* OR rain OR rainstorm* OR rainfall* OR downfall* OR downpour*) OR AB(storm* OR precipitation* OR rain OR rainstorm* OR rainfall* OR downfall* OR downpour*) OR SU(storm* OR precipitation* OR rain OR rainstorm* OR rainfall* OR downfall* OR downpour*)	137,824	2,823	4,791	4,013
S14	TI(snowstorm* OR (snow N2 storm*) OR snowfall* OR (snow N2 fall*) OR blizzard*) OR AB(snowstorm* OR (snow N2 storm*) OR snowfall* OR (snow N2 fall*) OR blizzard*) OR SU(snowstorm* OR (snow N2 storm*) OR snowfall* OR (snow N2 fall*) OR blizzard*)	2,377	82	123	120
S15	TI(thunderstorm* OR (thunder W0 storm*) OR lightning) OR AB(thunderstorm* OR (thunder W0 storm*) OR lightning) OR SU(thunderstorm* OR (thunder W0 storm*) OR lightning)	3,960	241	368	207
S16	TI(wind OR windstorm* OR (wind N2 storm*) OR tornado* OR twister* OR hurricane* OR cyclone*) OR AB(wind OR windstorm* OR (wind N2 storm*) OR tornado* OR twister* OR hurricane* OR cyclone*) OR SU(wind OR windstorm* OR (wind N2 storm*) OR tornado* OR twister* OR hurricane* OR cyclone*)	74,581	2,517	4,375	3,661
S17	TI((forest* W0 fire*) OR wildfire* OR (wild W0 fire*) OR bushfire* OR (bush W0 fire*)) OR AB((forest* W0 fire*) OR wildfire* OR (wild W0 fire*) OR bushfire* OR (bush W0 fire*))	11,971	266	367	327

	OR SU((forest* W0 fire*) OR wildfire* OR (wild W0 fire*) OR bushfire* OR (bush W0 fire*))				
S18	S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17	327,204	12,703	26,354	20,152
Concept 3 – Workers and workplaces					
S19	TI(occupational OR worker* OR workplace* OR working OR personnel OR professional* OR employee* OR job# OR labo#r OR volunteer*) OR AB(occupational OR worker* OR workplace* OR working OR personnel OR professional* OR employee* OR job# OR labo#r OR volunteer*) OR SU(occupational OR worker* OR workplace* OR working OR personnel OR professional* OR employee* OR job# OR labo#r OR volunteer*)	174,041	110,538	751,138	441,901
Concepts 1, 2, and 3 combined					
S20	S9 AND S18 AND S19	978	356	2,924	1,519
Language limit					
S21	S20 AND LA(French or English)	973	355	2,856	1,471
Date range					
S22	(performed manually) 2007-2017	809	228	1,766	648
Exclusion of letters, comments, editorials					
S23	S22 NOT PT(letter or commentary or editorial)	809	228	1,766	648

APPENDIX 3 EXAMPLE OF THE EVALUATION GRID FOR RESEARCH AVENUES SUBMITTED TO THE MONITORING COMMITTEE FOR THE PRIORITIZATION EXERCISE

Avenue number	Extreme weather event	Avenues for research or intervention (target group; target topic)	Relevance 1 = Very relevant 2 = Relevant 3 = Irrelevant	Urgency 1 = Very urgent 2 = Urgent 3 = Not urgent	Feasibility 1 = Very easy 2 = Easy 3 = Difficult	Impact 1 = Significant 2 = Medium 3 = Negligible	Total
1	Flooding	Avenue 1					
2	Flooding	Avenue 2					
3	Flooding	Avenue 3					
... 21	Heat	...Avenue 21					

APPENDIX 4 PUBLICATIONS REVIEWED BY TYPE OF EXTREME WEATHER EVENT

	Author(s)	EWE	Type of study	Data collection period	Country – region(s) studied	Number of workers (Q): questionnaire (I): interviews	Trades and occupations studied
1	Sutherland and Glendinning, 2008	Ice storm (January 1998) Scale: 100 mm of freezing rain and ice pellets fell in six days over a geographic area from the Georgian Bay in Ontario to the Bay of Fundy in New Brunswick	Cross-sectional, mixed methods	About 18 months after the storm (July 1999)	Canada – Ontario: counties of Lanark; Leeds and Grenville; Stormont, Dundas and Glengarry; and Prescott and Russell	171 (Q) 40 (I)	Agricultural producers
2	Maltais and Robichaud, 2009	Ice storm (January 1998) Scale: 100 mm of freezing rain and ice pellets fell in six days over a geographic area from the Georgian Bay in Ontario to the Bay of Fundy in New Brunswick	Cross-sectional, qualitative	More than 18 months after the storm (fall 1999)	Canada – Montérégie area, Québec	57 (I)	Volunteer and paid frontline responders (police officers, firefighters) and second responders (social workers, nurses, home care workers, workers from public and community organizations, etc.)
3	McKibben et al., 2010	Hurricanes and tropical storm (2004 season) Scale: Four hurricanes (Charley, Frances, Ivan, and Jeanne) and a tropical storm (Bonnie) in seven weeks.	Cross-sectional, quantitative	About nine months after the 2004 hurricane season	United States – state of Florida	2,249 (Q)	Public health workers

	Author(s)	EWE	Type of study	Data collection period	Country – region(s) studied	Number of workers (Q): questionnaire (I): interviews	Trades and occupations studied
4	Fullerton et al., 2013	Hurricanes and tropical storm (2004 season) Scale: Four hurricanes (Charley, Frances, Ivan, and Jeanne) and a tropical storm (Bonnie) in seven weeks	Cross-sectional, quantitative	About nine months after the 2004 hurricane season	United States – state of Florida	2,249 (Q)	Public health workers
5	Fullerton et al., 2015	Hurricanes and tropical storm (2004 season) Scale: Four hurricanes (Charley, Frances, Ivan, and Jeanne) and a tropical storm (Bonnie) in seven weeks	Cross-sectional, quantitative	About nine months after the 2004 hurricane season	United States – state of Florida	2,249 (Q)	Public health workers
6	Dass-Brailsford and Thomley 2012	Hurricane Katrina (August 2005)	Longitudinal (before and after), quantitative	T1: prior to the experience volunteering in New Orleans (exact time period unspecified) T2: within 24 hours of their return	United States – New Orleans, state of Louisiana	25 (Q)	Volunteer mental health professionals (psychologists, social workers, and counsellors) from the Midwestern United States (outside the affected area)
7	West et al., 2008	Hurricane Katrina (August 2005)	Cross-sectional, quantitative	About two months (eight weeks) after the hurricane	United States – New Orleans, state of Louisiana	912 (Q)	Police officers
8	Tak et al., 2007	Hurricane Katrina (August 2005)	Cross-sectional, quantitative	A little over three months (13 weeks) after the hurricane	United States – New Orleans, state of Louisiana	525 (Q)	Firefighters

	Author(s)	EWE	Type of study	Data collection period	Country – region(s) studied	Number of workers (Q): questionnaire (I): interviews	Trades and occupations studied
9	Ward and Shelley, 2008	Hurricane Katrina (August 2005)	Cross-sectional, mixed methods	About five months after the hurricane	United States – state of Mississippi	227 (Q)	School administrators
10	Osofsky et al., 2011	Hurricane Katrina (August 2005)	Longitudinal (before and after), quantitative	T1: six to nine months after the hurricane and T2: 13 to 18 months after the hurricane	United States – New Orleans, state of Louisiana	1,382 (Q)	First responders (municipal employees: firefighters, police officers, paramedics)
11	Yarbrough et al., 2007	Hurricane Katrina (August 2005)	Cross-sectional, qualitative	T1: one week to one month after the hurricane T2: about nine months after the hurricane	United States – states of Louisiana, Mississippi, and Texas	5 (I)	Volunteer social workers
12	Battles and Slidell, 2007	Hurricane Katrina (August 2005)	Cross-sectional, quantitative	Less than two years after the hurricane (unspecified)	United States – state of Louisiana	5 (I)	Nurses
13	Culver et al., 2011	Hurricane Katrina (August 2005)	Cross-sectional, mixed methods	About four years after the hurricane (2009)	United States – state of Louisiana, New Orleans area	30 (Q) 5 (I)	Mental health professionals
14	Bauwens and Tosone, 2014	Hurricane Katrina (August 2005)	Cross-sectional, quantitative	More than four years after the hurricane (January to May, 2010)	United States – states of Louisiana and Mississippi	244 (Q)	Graduates and professionals in: social workers and mental health clinicians
15	Tosone et al., 2015	Hurricane Katrina (August 2005)	Cross-sectional, quantitative	More than four years after the hurricane (January to May, 2010)	United States – states of Louisiana and Mississippi	244 (Q)	Graduates and professionals in social work: social workers and mental health clinicians
16	Adams and Turner, 2014	Hurricane Katrina (August 2005)	Cross-sectional, mixed methods	About four years after the hurricane (2009)	United States – city in a coastal state of the Gulf of Mexico (city and state not specified)	38 (Q) 36 (I)	Police officers of various ranks

	Author(s)	EWE	Type of study	Data collection period	Country – region(s) studied	Number of workers (Q): questionnaire (I): interviews	Trades and occupations studied
17	McCanlies et al., 2014	Hurricane Katrina (August 2005)	Cross-sectional, quantitative	More than six years after Hurricane Katrina (April 2012)	United States – New Orleans, state of Louisiana	114 (Q)	Police officers
18	Leppma et al., 2017	Hurricane Katrina (August 2005)	Cross-sectional, quantitative	More than six years after Hurricane Katrina (April 2012)	United States – New Orleans, state of Louisiana	113 (Q)	Police officers
19	Nicdao et al., 2013	Hurricanes Katrina and Rita (August and September 2005)	Cross-sectional, quantitative	About three months after the hurricanes	United States – states of Alabama, Louisiana, Mississippi, and Texas	505 (Q)	Student volunteers enrolled in undergraduate and graduate mental health programs from five universities located in the southernmost part of the country
20	Lemieux et al., 2010	Hurricanes Katrina and Rita (August and September 2005)	Cross-sectional, quantitative	About three months after the hurricanes	United States – coastal states of the Gulf of Mexico (unspecified)	416 (Q)	Volunteer students enrolled in university social work programs at four universities
21	Prost et al., 2016	Hurricanes Katrina and Rita (August and September 2005)	Cross-sectional, quantitative	About three months after the hurricanes	United States – coastal states of the Gulf of Mexico (unspecified)	416 (Q)	Volunteer students enrolled in university social work programs at four universities
22	Broussard et al., 2008	Hurricanes Katrina and Rita (August and September 2005)	Cross-sectional, qualitative	About six months after the hurricanes (March 2006)	United States – state of Louisiana	41 (I)	School nurses
23	Clukey, 2010	Hurricanes Katrina and Rita (August and September 2005)	Cross-sectional, qualitative	One year after the hurricanes	United States – states affected by the hurricanes (unspecified)	8 (I)	Volunteer workers
24	Lambert and Lawson, 2013	Hurricanes Katrina and Rita (August and September 2005)	Cross-sectional, quantitative	About four years after the hurricanes	United States – states of Texas, Louisiana and Mississippi	125 (Q)	Volunteer mental health professionals

	Author(s)	EWE	Type of study	Data collection period	Country – region(s) studied	Number of workers (Q): questionnaire (I): interviews	Trades and occupations studied
25	Raveis et al., 2017	Post-tropical cyclone Sandy (October 2012)	Cross-sectional, mixed methods	One-on-one interviews: six to eight months after Sandy (April to June 2013) Online survey: nine to 11 months after Sandy (July to September 2013)	United States – State of New York	528 (Q) 16 (I)	Nurses
26	Carra and Curtin, 2017	Flooding in the north central region of the state of Victoria in Australia (December 2010 to January 2011)	Cross-sectional, qualitative	30 to 36 months after the flooding (July to December 2013)	Australia – Shire of Loddon, state of Victoria	6 (I)	Woman agricultural producers
27	Biggs et al., 2014	Flooding in the state of Queensland in Australia (December 2010 to January 2011)	Longitudinal (before and after), quantitative	T1: about 10 months before flooding T2: about one month after flooding	Australia – state of Queensland	1,623 (Q)	Police officers
28	Carroll et al., 2010	Flooding in the city of Carlisle in the United Kingdom (December 2015)	Cross-sectional, qualitative	10 to 13 months after flooding	United Kingdom	6 (I)	Volunteer and paid municipal and charitable organization workers
29	Doley et al., 2016	Ash Wednesday bushfires in southern Australia (February 1983)	Longitudinal (cohort), quantitative	84 months (seven years) after the bushfires	Australia	277 (Q)	Volunteer firefighters
30	Cherry and Haynes, 2017	Fort McMurray wildfire (May 3, 2016)	Longitudinal (before and after), quantitative	T1: Not indicated T2: Questionnaire completed on average 101.5 days after the fire	Canada – Fort McMurray area, province of Alberta	130 (Q)	Various paid employees from the Fort McMurray area, including in the welding and electricity sectors

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