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Health professionals in a changing climate: Protocol for a scoping study

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Health professionals in a changing climate: Protocol for a scoping study

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ABSTRACT

Introduction Climate change will impose significant health impacts. Although we know health professionals should play critical role in protecting human health from climate change, health professionals' preparedness to engage with these issues worldwide is unclear. The objective of this study is to map the extent, range, and nature of evidence available regarding health professionals' preparedness in a changing climate and identify gaps to guide future research, policy, and practice.

Methods and analysis This is a scoping review using the six-stage framework developed by Arksey and O'Malley. Our study includes English-language peer-reviewed literature focusing on any aspect health professionals' work regarding climate change and health between 2002 and 2017 and indexed in MEDLINE/Pubmed, Web of Science, Scopus, or Embase. Identified papers will be described and themes identified and elaborated. Thematic analysis will be applied to evaluate and categorize study findings.

Implications and dissemination This is the first review of health professionals' activities to anticipate and prepare for climate change impacts on the health sector. It will provide evidence regarding current situations worldwide and gaps in preparedness. The findings can be used to highlight accomplishments to date, identify gaps, and further develop best practices for health professionals' engagement. Results will be published in the peer reviewed literature and shared at health sector professional society meetings.

STRENGTHS & LIMITATIONS OF THIS STUDY

1. The systematic scoping review will fill an important research gap, as evidence regarding health professionals' engagement and preparedness is beginning to accumulate but has not yet been collated and centrally assessed.
2. This search of multidisciplinary databases covering medicine, health, society and the environment will ensure a comprehensive assessment of published literature on the topic.
3. No restrictions will be applied on study type, design, location, or health professional role.
4. As non-English publications will be excluded, potentially relevant articles may be eliminated.
5. As we aim to synthesize all the different aspects with regard to climate change and health professionals, identified literature will not be excluded based on quality assessment, though the type of study and the strength of available evidence will be noted in the review.

INTRODUCTION

Climate change (or global warming) is one of the major public health issues of the 21st century. Climate change's impacts are already being observed today in the worldwide, and future projections represent an unacceptably high and potentially catastrophic risk to human health.[1 2] Climate change poses a range of health threats, many of which have the potential to interact and overlap. Some causal pathways are relatively short and direct (e.g., heat waves and extreme weather events such as storms, forest fires, and floods), while some are longer and health impacts are more indirectly mediated through socio-ecological systems (eg, agricultural losses and other nutritional impacts and changing patterns of disease), and changes in social structure (e.g., migration and conflict). The indirect consequences such as ecosystem collapse may drive the most significant health impacts but are more difficult to estimate using currently available methods. The Fifth Assessment Report (AR5) from the Intergovernmental Panel on Climate Change (IPCC) affirms that there is increasing certainty these impacts will continue and, in some cases, accelerate.[3] Significant adverse health impacts are at this point unavoidable and potentially irreversible, and the potential for prevention activities to blunt impacts has been limited by the delayed response to climate change over the past 25 years.[2]

Population vulnerability to these threats and thus risk of significant impacts varies by region, raising an important issue of health inequity, both globally from a north-south perspective and across individual societies. Extremes in heat and cold, air pollution, and increased allergens have heightened health impacts that are particularly threatening to vulnerable populations such as children, older adults, those with preexisting ill-conditions, and the poor.[4] Extreme weather events such as heavy rains, droughts, and tornados; flooding and contamination from sewage and chemicals from sea level rise; and disruptions to the social system such as economic insecurity, displacement, homelessness, and conflict affect multiple populations, though their impacts will more profoundly affect those vulnerable groups noted above as well as other socially marginalized groups.[1 4 5] The health effects of climate change are environmental justice issues that contribute to undue hardship and health disparities among the most vulnerable.[6]

Climate change will likely exacerbate many environmental health risks familiar to clinicians and public health professionals, and will create novel hardships and threats in many areas. Health professionals will play critical roles in preparing for and responding to the health threats related to climate change.[7 8] The voice of the health profession is essential in driving forward progress on climate change and maximizing an effective response. When asked to rank various potential sources of information about health consequences of global warming, the general public in the U.S. were most likely to trust their primary care physician, followed by the Centers for Disease Control and Prevention.[9] The health profession not only has the ability but the responsibility to act as public health advocates by communicating the opportunities and threats to policy makers and the general public, and ensuring climate change is fully understood as fundamentally related to human wellbeing.[10]

In general, health professionals can take many different actions, such advocating for implementation of mitigation measures in the health sector and generally; being vocal in framing climate change is a health problem; pushing for rapid attainment of sustainable development

goals, and speaking out to protect the most vulnerable populations to reduce poverty and inequity related to climate change; advocating for political leadership and high level intergovernmental bodies to reduce the risks of dangerous climate change; advocating the mass scale-up of currently available solutions (for example, renewable energy streams, improved energy efficiency in the building sector, rapid development of renewables, and technology transfer from high to middle- and low-income countries) in the health sector and beyond.[10] Increasingly, due to the climate change commitment from prior emissions, health professionals must also advocate strongly for adaptation measures in the health sector and other areas of the economy that affect health, such as water and agriculture. The 2016 WHO conference on climate change and health concluded with a clarion call to the health community: it is imperative that health professionals worldwide show strong leadership in tackling climate change.[7]

The extent to which health professionals around the world are prepared to act to reduce the likelihood of dangerous climate change and to respond adequately to health impacts, however, is unclear. Therefore, we will conduct a scoping study to fully understand what is known about health professionals' knowledge, engagement, preparedness activities, and other activities regarding to climate change and its health impacts as well as the health sector's ability to address these challenges.

Objectives and hypotheses

With this scoping literature review, we aim to collate published academic literature on climate change and health professionals. We will map the findings by categorizing papers according to various indicators and to provide a thematic analysis of their content.

The specific objectives are:

- To provide an overview of existing peer-reviewed literature over time regarding climate change and the health sector;
- To build a database of existing scientific papers that explores climate change and health professionals' preparedness from 2002 to 2017 and to categorize them according to specified criteria;
- To make recommendations based on the research trends observed and prospective areas for future research.

METHOD

Scoping review methodology

Systematic scoping reviews aim to rapidly synthesize evidence on crucial concepts associated with broad research topics in addition to identifying the central sources and forms of evidence available.[11] While methodological frameworks developed by Arksey and O'Malley (2005) and enhanced by Levac et al. (2010)[11 12] allow for more standardization, scoping review methods remain flexible to enable clarification of concepts and research questions following familiarization with the literature. [13]

Systematic scoping studies are beneficial in areas with emerging evidence, where evidence paucity prevents conduction of systematic reviews, and in areas with substantial diversity in approaches to the topic. In addition, by incorporating different study designs, scoping reviews allow the researchers to answer questions beyond intervention effectiveness.[12]

Undertaking a systematic scoping review will allow the authors to explore extensively the literature on the health professional's knowledge, attitude, perceptions, and practices regarding climate change and health impacts between 2002 and 2017. The review will combine knowledge resulting from different study types and designs in peer reviewed literature. Although quality assessment is not always conducted in scoping reviews,[12] the methodology applied to synthesize knowledge is rigorous and systematic, thereby demonstrating credible evidence.

Protocol Design

The review will apply the methodological approach delineated by Arksey and O'Malley (2005) and Levac et al.(2010).[11 12] There are six stages in the framework for conducting a scoping study: (1) identifying the research question, (2) identifying relevant studies, (3) selection of studies, (4) charting and presenting the data, (5) collating, summarizing and reporting results and (6) external consultation with relevant stakeholders.[11]

Stage 1: Identifying the research question

Climate change poses serious threats to human health and health professionals should play critical roles in combating the health risks. While some members of the health community are highly aware of the issues, we do not know how the health community more generally perceives and this problem and what actions it prioritizes, illustrating an evidence gap.

Therefore, we developed our specific research questions in Table 1.

Table 1 Research questions for 'climate change and health professionals' scoping review

Research questions	
1. What health professional roles have been studied regarding the health sector and climate change?	Doctors/physicians, Public health professionals, Nurses, General practitioners, administrators, educators, Other health professionals
2. What is the geographical origin and focus of the publications?	▸ Africa ▸ North America ▸ South America ▸ Antarctica ▸ Asia ▸ Australasia ▸ Europe
3. What types of articles are published on the topic?	▸ Original research ▸ Review ▸ Commentary/opinion/letter/view point/editorial

	▸ Protocol
4. With what institutions and professions are corresponding authors affiliated?	▸ Country ▸ Institution ▸ Profession
5. How do health professionals know about climate change and its health risk?	▸ Knowledge, attitude, and perceptions
6. How do health professionals take actions in response to climate change and health risk?	▸ Mitigation (renewable energy streams, greening health sector, etc.) ▸ Adaptation (risk and vulnerability assessment, research into harms and risk reduction, education and training, etc.)

Stage 2: Identifying relevant studies

The databases chosen for this review are MEDLINE/PubMed, Web of Science, Scopus, and Embase. The search strategy will include broad terms to cover all areas of climate change and health professionals. Following the development of MeSH terms, subject headings and keywords used to index articles, the search strategy will be reviewed by a Sun Yat-sen University medical librarian.

Table 2 shows the keywords that will be used for building the search strategy, as well as the range of publication dates. To capture as much relevant literature as possible, the search strategy will consist of free text and Medical Subject Headings (MeSH) terms.

Table 2 Search terms for 'climate change and health professional' scoping review

Climate change-related terms	Health professionals related terms	Date of publication
Climate change Global warming Climate variability Greenhouse effect/Greenhouse gas emissions(GHGE) Extreme weather/ Heat wave/ High temperature/ Drought/ Flooding	Health/ Medical/ Clinic/ Public health/ Healthcare professional/ worker/ technician/ technologist/ staff/ practitioner/ officer/ Assistant/ student Physician/ Physician Assistant General practitioner/ Nurse/ Doctor/ Intern Internist/ Surgeon/ psychiatrist/ Psychologist/ Endocrinologist/ Dentist/ odontologist/ obstetricians/ gynaecologists	2002-2017

Search syntaxes The key search terms will be adapted according to the different databases. Table 3 below outlines the detailed search syntaxes that will be used to search each database.

Table 3 Search strategy syntax for databases

Database	Search strategy syntax
PubMed	(climate change [Title/Abstract] OR global warming [Title/Abstract] OR climate variability [Title/Abstract] OR greenhouse effect [Title/Abstract] OR GHGE [Title/Abstract] OR Extreme weather

	[Title/Abstract] OR Heat wave [Title/Abstract] OR High temperature [Title/Abstract] OR Drought [Title/Abstract] OR Flooding [Title/Abstract]) AND ((Health [All Fields] OR Medical [All Fields] OR Clinic [All Fields] OR Public health [All Fields] OR Healthcare [All Fields] OR Health care [All Fields]) AND (Professional [All Fields] OR worker [All Fields] OR technician [All Fields] OR technologist [All Fields] OR staff [All Fields] OR practitioner [All Fields] OR officer [All Fields] OR Assistant [All Fields] OR student [All Fields]) OR Physician [All Fields] OR Physician Assistant [All Fields] OR General practitioner [All Fields] OR General doctor [All Fields] OR Nurse [All Fields] OR Doctor [All Fields] OR Intern [All Fields] OR Internist [All Fields] OR Surgeon [All Fields] OR Psychiatrist [All Fields] OR Psychologist [All Fields] OR Endocrinologist [All Fields] OR Dentist [All Fields] OR Odontologist [All Fields]) AND (2002/01/01 [PDAT]: 2017/12/31 [PDAT])
Web of Science	TI=(climate change OR global warming OR climate variability OR greenhouse effect OR GHGE OR Extreme weather OR Heat wave OR High temperature OR Drought OR Flooding) AND TS=((Health OR Medical OR Clinic OR Public health OR Healthcare OR Health care) AND (Professional OR worker OR technician OR technologist OR staff OR practitioner OR officer OR Assistant OR student) OR Physician OR Physician Assistant OR General practitioner OR General doctor OR Nurse OR Doctor OR Intern OR Internist OR Surgeon OR Psychiatrist OR Psychologist OR Endocrinologist OR Dentist OR Odontologist) AND TIME SPAN=(2002-2017)
Scopus	(TITLE-ABS-KEY ("climate change" OR "global warming" OR "climate variability" OR "greenhouse effect" OR "extreme weather" OR "heat wave" OR drought OR flooding) AND (TITLE-ABS-KEY (health OR medical OR "public health" OR healthcare OR clinic) AND TITLE-ABS-KEY ((professional OR worker OR staff OR practitioner OR technician OR technologist) OR doctor OR nurse OR physician OR intern OR internist OR surgeon OR psychiatrist OR psychologist OR endocrinologist OR dentist OR odontologist))) AND (PUBYEAR > 2001) AND (PUBYEAR < 2018)
Embase	('(climate change':ti,ab,kw OR 'global warming':ti,ab,kw OR 'climate variability':ti,ab,kw OR 'greenhouse effect':ti,ab,kw OR 'ghge':ti,ab,kw OR 'extreme weather':ti,ab,kw OR 'heat wave':ti,ab,kw OR 'high temperature':ti,ab,kw OR 'drought':ti,ab,kw OR 'flooding)':ti,ab,kw) AND ((('(health':ti,ab,kw OR 'medical':ti,ab,kw OR 'clinic':ti,ab,kw OR 'public health':ti,ab,kw OR 'healthcare':ti,ab,kw OR 'health care)':ti,ab,kw) AND '(professional':ti,ab,kw OR 'worker':ti,ab,kw OR 'technician':ti,ab,kw OR 'technologist':ti,ab,kw OR 'staff':ti,ab,kw OR 'practitioner':ti,ab,kw OR 'officer':ti,ab,kw OR 'assistant':ti,ab,kw OR 'student)':ti,ab,kw OR 'physician':ti,ab,kw OR 'physician assistant':ti,ab,kw OR 'general practitioner':ti,ab,kw OR 'general doctor':ti,ab,kw OR 'nurse':ti,ab,kw OR 'doctor':ti,ab,kw OR 'intern':ti,ab,kw OR 'internist':ti,ab,kw OR 'surgeon':ti,ab,kw OR 'psychiatrist':ti,ab,kw OR 'psychologist':ti,ab,kw OR 'endocrinologist':ti,ab,kw OR 'dentist':ti,ab,kw OR

'odontologist) ':ti,ab,kw) AND [2002-2017]/py

MeSH, Medical Subject Headings.

Stage 3: Study Selection and Eligibility Criteria

We will use the EndNote software to remove duplicates of references searched by our research team. Table 4 below outlines the inclusion and exclusion criteria that will be used to conduct the literature review.

The review process consists of two stages: the first stage by screening of titles and abstracts and, the second one, by full-text screening. Based on the review's predetermined inclusion and exclusion criteria, titles, keywords and abstracts of papers will then be screened by two independent reviewers, as recommended by Levac et al.[12] Ineligible papers will be eliminated. In the next, titles, keywords and abstracts that appear to meet the review's eligibility criteria will be subjected to full-text reading. If the two primary reviewers cannot reach a consensus on study eligibility, a third reviewer will assist in the selection process. A PRISMA flow diagram will be used to demonstrate the review's selection process and exclusion reasons, demonstrating replicability and transparency. This stage will represent an iterative process, incorporating search of the literature, refinement of search strategies and selection of articles.[12]

Table 4 Inclusion and exclusion criteria for scoping review

Inclusion criteria	Exclusion criteria
• Peer-reviewed articles (including original quantitative and qualitative studies, systematic reviews, editorials, viewpoints, comments) • Indexed in MEDLINE/PubMed, Web of Science, Scopus, and Embase databases • Articles published between 2002 and 2017 • Focus on climate change and health professionals • Publications in English only • No restriction to country or population	• Book chapters and grey literature (dissertations, conference proceedings, reports, etc.).

Stage 4: Charting the data

Using predetermined data charting forms will be used to retrieve data from included papers. Extracted data will include author, study type, publication date, study characteristics (location, climate change type, institutional setting [e.g. hospital, community health center, disease control and prevention center, medical college/university]), health professional characteristics, their knowledge, perception, behavior and action details on climate change (age, gender, profession, interventions and measures, views and visions, wiliness to act, resources support).

The review will map the climate change and health professionals' perceptions and practices between 2002 and 2017 in climate change and health literature. To assure that all relevant data is

collected adequately, the forms used for data extraction will be reviewed by the research team prior to implementation. Data extraction will be conducted independently by two reviewers before comparing forms. Differences will be discussed (if necessary with a third reviewer) before producing a single form containing the required data.

Further, a qualitative thematic analysis approach will be applied to categorize and present the key themes in our data. This is a commonly used method for scoping reviews and it involves identifying themes across the literature and synthesizing using summary tables with some thematic headings.

Stage 5: Collating, summarizing and reporting results

Systematic scoping reviews provide an overview by answering broad questions.[11] Following data extraction, results will be presented: (i) numerically - synopsis of the amount and type of included studies and (ii) narratively - a synthesis of all included studies. We will develop a matric framework for reviewing different questions. For example, the roles of health professionals can be identified from micro-, meso- and macro-levels. Under each level, there are different perceptions and actions.

The authors will discuss implications of the findings on future research, practice and policy.[12] To provide a holistic analysis, the all different aspects regarding to health professionals' preparedness regarding climate change will be collected. This will consist of data including, but not limited to knowledge, attitude, practices and behaviors, interventions and programs, development resources and financial support. We believe that this approach will allow us to determine the current situation of health professionals' preparedness in response to climate change, and to find the evidence gap then develop effective measures to enhance their knowledge and practice skills.

Stage 6: Consultation

Public health professionals, professors and experts from School of Public Health of Peking University, Chinese Center for Disease Control and Prevention, Department of Primary Care & Public Health of Imperial College (UK), London Hygiene and Tropical Medicine School (UK), George Mason University (USA), will be consulted, thus providing valuable insights beyond what has been captured through literature search. Our research team has close collaboration with the above institutions, and these institutions have rich experiences and extensive researches in the field of capacity building, health professionals' knowledge, perceptions and actions on the climate change.

Knowledge dissemination & translation

Following completion of the scoping review, health professionals' perceptions, preparedness and actions regarding to climate change over the last 16 years will be determined, yielding gaps as well as important policy, practice and research recommendations.

In addition to developing recommendations that align the needs of health professionals, approaches for engagement and empowerment of health professionals, which remain to be

targeted, will be considered and disseminated. Study findings will be disseminated through report materials and publication of the review in a peer-reviewed journal.

Unless health professionals comprehensively perceive and actively communicate the impacts of climate change, knowledge of detrimental health effects will be limited to concerned scientific communities, and health protection will not be adequate. Hence, through publication and circulation of our results on academic and lay websites, the authors aspire to develop an effective dissemination strategy to publicize recommendations to enhance health professional's engagement.

Aspiring to tackle the greatest global health challenge of our time,[1] we aim to utilize the knowledge gained from the review to develop for health professionals an engagement and empowerment package which will improve their knowledge and awareness, over time, elicit individual behavioral change and enhance their capacity. We also intend for the collected evidence to support collective, high-level action in health departments locally, nationally, and internationally.

CONCLUSION

It is important to raise the awareness of and empowerment the health professionals in tackling climate change and its health risks. Around the world, we are not clear about health professionals' engagement in mitigation activities or their preparedness to address the challenges climate change will pose. The review's findings will enable the development of improved and effective interventional approaches, materials, tools, and content on climate change and health that will enhance the health professional's engagement to overcome this global challenge.

ETHICS AND DISSEMINATION

No ethical approval was required for this literature-based study.

The extraction and categorization of publications for climate change and health professionals will provide a long-term overview of the published literature on this topic. We will build an open access database of our findings, which will be updated over time and serve as a useful source of information for practitioners and researchers working in this field. The findings will be disseminated through a peer-reviewed journal and will also be reported at local, national and international conferences on climate change and public health.

CONTRIBUTORS

LPY wrote the first draft of the paper and initiated the project and data collection. CJL and CRH advised on study design, study methods and revised the draft paper. JJH and DP advised on study methods and revised the draft paper. All authors approved the final version of the paper.

COMPETING INTERESTS None declared.

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PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	3
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	6-7
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	8
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	8-9
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	8-9
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	NA
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	NA
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency	9

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	NA
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	9-10
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	NA
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	NA
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	NA
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	NA
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	NA
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	NA
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	NA
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	NA
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	NA
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	10
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	10-11

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ABSTRACT

Introduction Climate change will impose significant health impacts. Although we know health professionals should play a critical role in protecting human health from climate change, their preparedness to engage with these issues worldwide is unclear. This study aims to map the range and nature of existing evidence regarding health professionals' preparedness in a changing climate and identify knowledge gaps to guide future development of research, policy and practices.

Methods and analysis We performed a scoping review based on the six-stage framework proposed by Arksey and O'Malley. Our study includes peer-reviewed literature focusing on any aspect of health professionals' work regarding climate change and health since 2002 and indexed in MEDLINE/Pubmed, Web of Science, Scopus, or Embase. Identified papers will be described and assessed. Thematic analysis will be applied to evaluate and categorize the study findings.

Implications and dissemination This is the first scoping review of health professionals' activities to anticipate and prepare for health impacts attributable to climate change. It will provide evidence regarding the current situations worldwide and gaps in preparedness. The findings can be used to highlight accomplishments to date, identify gaps, and further develop good practices for health professionals' engagement. The results will be published in the peer reviewed literature and shared at health professional society meetings.

STRENGTHS & LIMITATIONS OF THIS STUDY

1. The systematic scoping review study will fill an important research gap, as evidence regarding health professionals' engagement and preparedness is beginning to accumulate but has not yet been collated and centrally assessed.
2. This review will search multidisciplinary databases covering medicine, health, society and the environment in order to ensure a comprehensive assessment of the literature.
3. No restrictions will be applied on study type, design, location, or health professional role.
4. As we aim to synthesize all the different aspects with regard to climate change and health professionals, identified literature will not be excluded based on quality assessment, though the type of study and the strength of available evidence will be noted in the review.
5. As full-text review will not apply to the small number of publications in a language other than English and Chinese, the review report may be biased.

INTRODUCTION

Climate change (or global warming) is one of the major global health concerns of the 21st century. Climate change's impacts are already being observed today worldwide. If no actions are taken, the risk to human health will be unacceptably high and potentially catastrophic.[1 2] Climate change poses a range of health threats, many of which have the potential to interact and overlap. Some causal pathways are relatively short and direct (e.g., heat waves, storms, floods and forest fires), while some are longer and their health impacts are more indirectly mediated through socio-ecological systems (e.g., agricultural losses and other nutritional impacts and changing patterns of infectious disease) and changes in social structure (e.g., human migration and community conflicts). The indirect consequences such as ecosystem collapse may drive the most significant health impacts but are more difficult to estimate using currently available methods. The Fifth Assessment Report (AR5) from the Intergovernmental Panel on Climate Change (IPCC) affirms that "*there is increasing certainty these [impacts] will continue and, in some cases, accelerate*".[3] Significant adverse health impacts are at this point unavoidable and potentially irreversible, and the potential for prevention activities to blunt impacts has been limited by the slow and inadequate response to the changing climate over the past two decades.[2]

Population vulnerability to these threats and thus risk of significant impacts varies by region, raising an important issue of health inequity, both globally from a north-south perspective and across individual societies. Disadvantaged populations such as the elderly, children and those with preexisting ill-conditions are particularly vulnerable to heat, cold, allergens and air pollution as a result of extreme weather events.[4] The poor and other socially marginalized groups are disproportionally affected by these extreme weather events. They suffer more profoundly from disruptions to the social system such as economic insecurity, displacement, homelessness, and conflict.[1 4 5] Researchers believe that the health impacts of climate change are a consequence of environmental justice issues.[6]

Climate change will likely exacerbate lots of environmental health risks familiar to public health professionals and clinical workers, and will create novel hardships and threats in many areas. Health professionals should play critical roles in addressing the health threats related to climate change.[7 8] The voice coming from the health profession is vital in raising public awareness and driving political agenda on climate change. In the US, the general public were most likely to trust their primary care physicians followed by the Centers for Disease Control and Prevention (CDC) in obtaining information about health consequences of global warming.[9] The health profession can act as advocates for population health by communicating the opportunities and threats to policy makers and the general public.[10]

In general, health professionals can take many different actions, such as advocating for implementation of mitigation measures in the health sector and generally; being vocal in framing climate change is a public health issue; pushing for rapid attainment of the United Nations SDGs (sustainable development goals), and speaking out to protect the vulnerable groups to reduce poverty and inequity related to climate change; advocating for political leadership at the local, national and international levels to reduce the risks of dangerous climate change; promoting the available solutions (for example, renewable energy streams, improved energy efficiency, and

technology transfer from high-income to middle- and low-income countries) in the health sector and beyond.[10] Increasingly, due to the climate change commitment from prior emissions, health professionals must also advocate strongly for adaptation measures in the health sector and other areas of the economy that affect health, such as water and agriculture. The 2016 "WHO conference on climate change and health" concluded with a loud and clear call to the international health community: "*it is imperative that health professionals worldwide show strong leadership in tackling climate change*".[7] The U.S. CDC's Climate Ready States and Cities Initiative (CRSCI) represents a useful example for health professionals to move forward and engage in robust, targeted local preparedness and response. [11]

The extent to which health professionals around the world are prepared to act to reduce the likelihood of dangerous climate change and to respond adequately to health impacts, however, is unclear. Therefore, we will conduct a scoping study to fully understand what is known about health professionals' knowledge, engagement, preparedness activities, and other activities regarding climate change and its health impacts as well as the hurdles and challenges health professionals face in realizing their full potentials.

Research objectives

In this scoping review study, the objectives are to collate published academic literature/papers on climate change and health professionals. We aim to map the findings by categorizing papers according to their topic and context information, establish an open database of relevant literature, and provide a thematic analysis on the content.

The specific objectives of this study include:

- providing an overview of existing peer-reviewed literature over time regarding climate change and health professionals;
- establishing an open database of categorized literature regarding climate change and health professionals' preparedness;
- making recommendations on the roles of health professionals in climate change and potential areas for future research.

METHOD

Patient and Public Involvement

This is a review study and there is no patient and public involvement.

Scoping review methodology

The aim of systematic scoping reviews is to rapidly synthesize "*evidence on crucial concepts associated with broad research topics in addition to identifying the central sources and forms of evidence available*".[12] While methodological frameworks developed by Arksey and O'Malley (2005) and enhanced by Levac et al. (2010)[12 13] allow for more standardization, scoping review methods "*remain flexible to enable clarification of concepts and research questions following familiarization with the literature*". [14]

Systematic scoping studies incorporate different study types and designs. It goes beyond answering questions about intervention effectiveness. Rigorous and systematic methods apply to demonstrate credible evidence for synthesizing knowledge. This is beneficial when shortage of evidence prevents conduct of systematic reviews, and when there exists substantial diversity in approaches to the topic.[13]

Undertaking a systematic scoping review will allow the researchers to explore extensively the academic literature on the health professional's knowledge, attitude, perceptions, and practices regarding climate change and health impacts and the challenges they face.

Protocol Design

The review will apply the methodological approach proposed by Arksey and O'Malley (2005) and Levac et al. (2010).[12 13] They delineated a six-stage framework for operating a scoping review study: (1) identifying the research gap and the questions, (2) identifying relevant literature, (3) assessment and selection of studies, (4) charting and presenting the data, (5) collating, summarizing and reporting findings and (6) external consultation with relevant stakeholders.[12]

Stage 1: Identifying the research question

Climate change poses serious threats to population health and health professionals should play critical roles in combating the health risks. While some members of the health community are highly aware of the issues, we do not know how the health community more generally perceives this problem and what actions it prioritizes, illustrating an evidence gap. Therefore, we developed our specific research questions (Table 1).

Table 1 Research questions for the scoping review on 'climate change and health professionals'

Research questions	
1. What health professional roles have been studied regarding the health impacts of climate change?	Doctors/physicians, Public health professionals, Nurses, General practitioners, administrators, educators, Other health professionals
2. What is the geographical origin and focus of the publications?*	▸ Africa ▸ the Americas ▸ South-East Asia ▸ Europe ▸ the Eastern Mediterranean ▸ the Western Pacific
3. What types of literature are published on climate change and health professionals?	▸ Original research ▸ Review ▸ Commentary/opinion/letter/view point/editorial ▸ Protocol
4. With what institutions and professions are corresponding authors affiliated?	▸ Country ▸ Institution

	▸ Profession
5. How do health professionals know about climate change and its health risk?	▸ Knowledge, attitude, and perceptions
6. How do health professionals take actions in response to climate change and health risk?	▸ Mitigation (renewable energy streams, greening health sector, etc.) ▸ Adaptation (risk and vulnerability assessment, research into harms and risk reduction, education and training, etc.)
7. What hurdles do health professionals face in taking actions?	▸International ▸National ▸Organizational

* Categorization of regions by the World Health Organization

Stage 2: Identifying relevant studies

Relevant studies will be identified from MEDLINE/PubMed, Web of Science, Scopus, and Embase. The search strategy will include terms broad enough to cover all areas of climate change and health professionals, including Medical Subject Headings (MeSH) terms, subject headings and keywords applied to identify articles. The search strategy in the different databases will be reviewed by a Sun Yat-Sen University medical librarian.

The search strategy will be built based on the keywords demonstrated in Table 2. A preliminary search identified the earliest relevant study published in 2006. In the scoping study, we will wind five years back to 2002. To capture as many relevant studies as possible, the search strategy will allow both MeSH terms and free text.

Table 2 Search terms for the scoping review on 'climate change and health professional'

Climate change-related terms	Health professionals related terms	Date of publication
Climate change Climate variability Global warming Greenhouse effect/Greenhouse gas emissions(GHGE) Extreme weather/ Heat wave/ High temperature/ Drought/ Flooding	Health/ Medical/ Clinic/ Public health/ Healthcare professional/ worker/ technician/ technologist/ staff/ practitioner/ officer/ Assistant/ student Physician/ Physician Assistant General practitioner/ Nurse/ Doctor/ Intern Internist/ Surgeon/ psychiatrist/ Pediatrician/ Psychologist/ Endocrinologist/ Dentist/ odontologist/ obstetricians/ gynaecologists	Since 2002

Search syntaxes The key search terms of this study will be adapted to the requirements of different databases. The detailed search syntaxes are adapted from the review on Osama T, et al. 2018.[15] and outlined in Table 3.

Table 3 Search strategy syntax for different databases

Database	Search strategy syntax

PubMed	(climate change [Title/Abstract] OR climate variability [Title/Abstract] OR global warming [Title/Abstract] OR greenhouse effect [Title/Abstract] OR GHGE [Title/Abstract] OR Extreme weather [Title/Abstract] OR Heat wave [Title/Abstract] OR High temperature [Title/Abstract] OR Drought [Title/Abstract] OR Flooding [Title/Abstract]) AND ((Health [All Fields] OR Medical [All Fields] OR Clinic [All Fields] OR Public health [All Fields] OR Healthcare [All Fields] OR Health care [All Fields]) AND (Professional [All Fields] OR worker [All Fields] OR technician [All Fields] OR technologist [All Fields] OR staff [All Fields] OR practitioner [All Fields] OR officer [All Fields] OR Assistant [All Fields] OR student [All Fields]) OR Physician [All Fields] OR Physician Assistant [All Fields] OR General practitioner [All Fields] OR General doctor [All Fields] OR Nurse [All Fields] OR Doctor [All Fields] OR Intern [All Fields] OR Internist [All Fields] OR Surgeon [All Fields] OR Pediatrician [All Fields] OR Psychiatrist [All Fields] OR Psychologist [All Fields] OR Endocrinologist [All Fields] OR Dentist [All Fields] OR Odontologist [All Fields]) AND (2002/01/01 [PDAT]: [PDAT])
Web of Science	TI=(climate change OR climate variability OR global warming OR greenhouse effect OR GHGE OR Extreme weather OR Heat wave OR High temperature OR Drought OR Flooding) AND TS=((Health OR Medical OR Clinic OR Public health OR Healthcare OR Health care) AND (Professional OR worker OR technician OR technologist OR staff OR practitioner OR officer OR Assistant OR student) OR Physician OR Physician Assistant OR General practitioner OR General doctor OR Nurse OR Doctor OR Intern OR Internist OR Surgeon OR Psychiatrist OR Pediatrician OR Psychologist OR Endocrinologist OR Dentist OR Odontologist) AND TIME SPAN=(2002-)
Scopus	(TITLE-ABS-KEY ("climate change" OR "climate variability" OR "global warming" OR "greenhouse effect" OR "extreme weather" OR "heat wave" OR drought OR flooding) AND (TITLE-ABS-KEY (health OR medical OR "public health" OR healthcare OR clinic) AND TITLE-ABS-KEY ((professional OR worker OR staff OR practitioner OR technician OR technologist) OR doctor OR nurse OR physician OR intern OR internist OR surgeon OR Pediatrician OR psychiatrist OR psychologist OR endocrinologist OR dentist OR odontologist))) AND (PUBYEAR > 2001)
Embase	('(climate change':ti,ab,kw OR 'climate variability':ti,ab,kw OR 'global warming':ti,ab,kw OR 'greenhouse effect':ti,ab,kw OR 'ghge':ti,ab,kw OR 'extreme weather':ti,ab,kw OR 'heat wave':ti,ab,kw OR 'high temperature':ti,ab,kw OR 'drought':ti,ab,kw OR 'flooding)':ti,ab,kw) AND ((('(health':ti,ab,kw OR 'medical':ti,ab,kw OR 'clinic':ti,ab,kw OR 'public health':ti,ab,kw OR 'healthcare':ti,ab,kw OR 'health care)':ti,ab,kw) AND '(professional':ti,ab,kw OR 'worker':ti,ab,kw OR 'technician':ti,ab,kw OR 'technologist':ti,ab,kw OR 'staff':ti,ab,kw OR 'practitioner':ti,ab,kw OR 'officer':ti,ab,kw OR 'assistant':ti,ab,kw OR 'student)':ti,ab,kw OR 'physician':ti,ab,kw OR 'physician assistant':ti,ab,kw OR 'general practitioner':ti,ab,kw OR 'general doctor':ti,ab,kw OR 'nurse':ti,ab,kw OR 'doctor':ti,ab,kw OR

	'intern':ti,ab,kw OR 'internist':ti,ab,kw OR 'surgeon':ti,ab,kw OR 'Pediatrician':ti,ab,kw OR 'psychiatrist':ti,ab,kw OR 'psychologist':ti,ab,kw OR 'endocrinologist':ti,ab,kw OR 'dentist':ti,ab,kw OR 'odontologist))':ti,ab,kw) AND [2002-]/py

MeSH, Medical Subject Headings.

Stage 3: Study Selection and Eligibility Criteria

We will use the EndNote software to remove duplicates of references searched by our research team.

The review process includes two stages: the first stage will screen titles and abstracts in English and the second stage will screen full-text in English and Chinese. Two independent reviewers will screen titles, keywords and abstracts of papers as recommended by Levac et al[13] based on the inclusion and exclusion criteria determined by the research team (Table 4). Those that meet all of the eligibility criteria of inclusion will be subjected to full-text reading. Due to resource restrictions, we will not review the full-text of articles published in a language other than English or Chinese unless their volume accounts for more than 20% of the identified abstracts. The two primary reviewers will resolve inconsistency in study eligibility, if exists, through discussions, before a third reviewer will be called upon to assist in the paper selection process. The selection process including exclusion reasons will be recorded using a PRISMA flow diagram to ensure replicability and transparency.

Stage 3 will be an iterative process, incorporating repeated attempts in search of the literature, adjustment of search strategies and selection of papers.[13]

Table 4 Inclusion and exclusion criteria for the selection of articles (adapted from Osama T. etc, 2018) [15]

Inclusion criteria	Exclusion criteria
• Peer-reviewed articles without restriction on type of publications, including original quantitative and qualitative studies, reviews, viewpoints, editorials, and commentaries. • Indexed in MEDLINE/PubMed, Web of Science, Scopus, and Embase databases • Articles published since 2002 • Focus on health professionals's roles in climate change • Publications in English and Chinese • No restriction to geographical origin or population	• Book chapters and grey literature (such as, conference proceedings, dissertations, reports, etc.).

Stage 4: Charting the data

A data charting form will be developed to guide data extraction from the eligible papers, including author, publication date, study type, study characteristics (location, climate change type, institutional setting [e.g. hospital, community health center, disease control and prevention center, medical college/university]), health professional characteristics, their knowledge, perception, behavior and action details on climate change (age, gender, profession, interventions and measures, views and visions, willingness to act, resources support), and hurdles and challenges identified. The charting form will be reviewed and discussed by the research team prior to the implementation to ensure comprehensiveness and completeness.

The review will map the climate change and health professionals' knowledge, perceptions and practices. Two reviewers will conduct data extraction independently. The two forms will then be compared and reconciled through discussions. If necessary, a third reviewer will be involved before a single form containing the required data is finalized.

Further, a qualitative thematic analysis approach will be applied to categorize and present the key themes in our data. This is a common way for scoping reviews. It involves coding the contents in the literature, identifying common themes across the literature, and synthesizing the logic link across the identified themes.

Stage 5: Collating, summarizing and reporting results

Systematic scoping review studies provide an overview on a broad range of aspects of studies.[12] Usually, the results will include a numerical synopsis of the amount and type of eligible studies and a narrative synthesis of the contents of included studies. We will develop a matrix framework for reviewing different aspects of the studies. For example, the roles of health professionals can be identified from micro-, meso- and macro-levels.[10 16] Under each level, there are different perceptions and actions.

The authors will discuss practice and policy implications of the findings, as well as the need for further studies in the future.[13] To ensure a robust and holistic analysis, all different aspects of health professionals' preparedness regarding climate change will be collected. These will include, but not limited to knowledge, attitude, practices and behaviors, interventions and programs, development resources, and legal, organizational and financial support. It's believed that this method will allow us to determine the current situation of health professionals' preparedness in response to climate change, and to find the evidence gap to inform the development of measures to enhance their knowledge and practice skills.

We will perform quality appraisal on the included studies using a rating framework developed by the research team based on the EQUATOR resources (www.equator-network.org/). We will make the quality rating framework and results available in the open access database. But we will not incorporate the quality appraisal in the review report because that is not customary for a scoping review.

Stage 6: Consultation

Public health professionals, professors and experts from the School of Public Health of Peking University, the Chinese Center for Disease Control and Prevention, the Department of Primary

Care & Public Health of Imperial College (UK), London Hygiene and Tropical Medicine School (UK), and George Mason University (USA) will be consulted. They will offer valuable insights that are not captured through the literature review. At least one workshop will be organized supplemented by one-on-one meetings (face-to-face and online). Our research team has close collaboration with the above institutions, and these institutions have rich experiences and extensive studies in the field of capacity building, health professionals' knowledge, perceptions and actions on climate change. We will record and incorporate the results of consultations into the review report.

Knowledge dissemination & translation

Following completion of the scoping review, health professionals' perceptions, preparedness and actions regarding climate change over the last 16 years will be determined, yielding gaps as well as important policy, practice and research recommendations. Our recommendations will be tailored to the needs of health professionals, considering approaches for engaging and empowering health professionals. The scoping findings will be communicated and disseminated through reports and publications of the review.

Health professionals can play a vital role in communication and advocacy on climate change mitigation and adaptation. It is important that health professionals comprehensively perceive and actively communicate the health impacts of climate change. If knowledge of detrimental health effects is limited to concerned scientific communities only, health protection will not be adequate. Hence, through publication and circulation of our results on academic and lay websites, the authors aspire to develop an effective dissemination strategy to publicize recommendations to enhance health professionals' engagement.

We aim to utilize the knowledge achieved from this scoping review to develop an engagement and empowerment package for health professionals which will improve their knowledge and awareness, elicit individual behavioral change and enhance their capacity.[1] We also intend for the collected evidence to support collective, high-level actions locally, nationally, and internationally in order to address this great global health challenge in a changing climate.[1]

CONCLUSION

It is important to raise the awareness of and empower the health professionals in tackling climate change and its health risks. Around the world, we do not know about health professionals' engagement in mitigation activities or their preparedness to address the challenges of climate change. The findings of the review will enable the development of effective interventional measures and tools on the health impacts of climate change that will enhance the health professionals' engagement to address this global challenge.

ETHICS AND DISSEMINATION

No ethical approval was required for this literature-based study.

We will build an open access database of the identified literature, which will serve as a useful source of information for practitioners and researchers working on this topic. It will be updated

over time and offer a comprehensive and long-term overview of the published literature on this topic. The findings will be disseminated through peer-reviewed journals, conferences at various levels, and reports available to the general public.

CONTRIBUTORS

LPY wrote the first draft of the paper and initiated the project and data collection. CJL and CRH advised on study design, study methods and revised the draft paper. JJH and DP advised on study methods and revised the draft paper. All authors approved the final version of the paper.

COMPETING INTERESTS None declared.

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PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	3
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4-5
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4-5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	6-7
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	8
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	8-9
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	8-9
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	NA
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	NA
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I²) for each meta-analysis.	9-10

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	NA
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	9-10
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	NA
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	NA
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	NA
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	NA
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	NA
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	NA
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	NA
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	NA
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	NA
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	11
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	11

BMJ Open

Health professionals in a changing climate: Protocol for a scoping review

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Health professionals in a changing climate: Protocol for a scoping review

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Word Count: 3213

ABSTRACT

Introduction Climate change will impose significant health impacts. Although we know health professionals should play a critical role in protecting human health from climate change, their preparedness to engage with these issues worldwide is unclear. This study aims to map the range and nature of existing evidence regarding health professionals' knowledge, attitudes, perceptions and practices regarding climate change and health impacts and the challenges they face, and identify knowledge gaps to guide future development of research, policy and practices.

Methods and analysis We will perform a scoping review based on the six-stage framework proposed by Arksey and O'Malley. Our study includes peer-reviewed literature focusing on any aspect of health professionals' work regarding climate change and health since 2002 and indexed in MEDLINE/Pubmed, Web of Science, Scopus, or Embase. Identified papers will be described and assessed. Thematic analysis will be applied to evaluate and categorize the study findings.

Implications and dissemination This is the first scoping review of health professionals' activities to anticipate and prepare for health impacts attributable to climate change. It will provide evidence regarding the current situations worldwide and gaps in preparedness. The findings can be used to highlight accomplishments to date, identify gaps, and further develop good practices for health professionals' engagement. The results will be published in the peer reviewed literature and shared at health professional society meetings.

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2. This review will search multidisciplinary databases covering medicine, health, society and the environment in order to ensure a comprehensive assessment of the literature.
3. No restrictions will be applied on study type, design, location, or health professional role.
4. As we aim to synthesize all the different aspects with regard to climate change and health professionals, identified literature will not be excluded based on quality assessment, though the type of study and the strength of available evidence will be noted in the review.
5. As full-text review will not apply to the small number of publications in a language other than English and Chinese, the review report may be biased.

INTRODUCTION

Climate change (or global warming) is one of the major global health concerns of the 21st century. Climate change's impacts are already being observed today worldwide. If no actions are taken, the risk to human health will be unacceptably high and potentially catastrophic.[1 2] Climate change poses a range of health threats, many of which have the potential to interact and overlap. Some causal pathways are relatively short and direct (e.g., heat waves, storms, floods and forest fires), while some are longer and their health impacts are more indirectly mediated through socio-ecological systems (e.g., agricultural losses and other nutritional impacts and changing patterns of infectious disease) and changes in social structure (e.g., human migration and community conflicts). The indirect consequences such as ecosystem collapse may drive the most significant health impacts but are more difficult to estimate using currently available methods. The Fifth Assessment Report (AR5) from the Intergovernmental Panel on Climate Change (IPCC) affirms that "*there is increasing certainty these [impacts] will continue and, in some cases, accelerate*".[3] Significant adverse health impacts are at this point unavoidable and potentially irreversible, and the potential for prevention activities to blunt impacts has been limited by the slow and inadequate response to the changing climate over the past two decades.[2]

Population vulnerability to these threats and thus risk of significant impacts varies by region, raising an important issue of health inequity, both globally from a north-south perspective and across individual societies. Disadvantaged populations such as the elderly, children and those with preexisting ill-health are particularly vulnerable to heat, cold, allergens and air pollution as a result of extreme weather events.[4] The poor and other socially marginalized groups are disproportionally affected by these extreme weather events. They suffer more profoundly from disruptions to the social system such as economic insecurity, displacement, homelessness, and conflict.[1 4 5] Researchers believe that the health impacts of climate change are a consequence of environmental justice issues.[6]

Climate change will likely exacerbate lots of environmental health risks familiar to public health professionals and clinical workers, and will create novel hardships and threats in many areas. Health professionals should play critical roles in addressing the health threats related to climate change.[7 8] The voice coming from the health profession is vital in raising public awareness and driving political agenda on climate change. In the US, the general public were most likely to trust their primary care physicians followed by the Centers for Disease Control and Prevention (CDC) in obtaining information about health consequences of global warming.[9] The health profession can act as advocates for population health by communicating the opportunities and threats to policy makers and the general public.[10]

In general, health professionals can take many different actions, such as advocating for implementation of mitigation measures in the health sector and generally; being vocal in framing climate change as a public health issue; pushing for rapid attainment of the United Nations SDGs (sustainable development goals), and speaking out to protect the vulnerable groups to reduce poverty and inequity related to climate change; advocating for political leadership at the local, national and international levels to reduce the risks of dangerous climate change; promoting the available solutions (for example, renewable energy streams, improved energy efficiency, and

technology transfer from high-income to middle- and low-income countries) in the health sector and beyond.[10] Increasingly, due to the climate change commitment from prior emissions, health professionals must also advocate strongly for adaptation measures in the health sector and other areas of the economy that affect health, such as water and agriculture. The 2016 "WHO conference on climate change and health" concluded with a loud and clear call to the international health community: "*it is imperative that health professionals worldwide show strong leadership in tackling climate change*".[7] The U.S. CDC's Climate Ready States and Cities Initiative (CRSCI) represents a useful example for health professionals to move forward and engage in robust, targeted local preparedness and response. [11]

The extent to which health professionals around the world are prepared to act to reduce the likelihood of dangerous climate change and to respond adequately to health impacts, however, is unclear. Therefore, we will conduct a scoping review to fully understand what is known about health professionals' knowledge, attitudes, perceptions and practices regarding climate change and its health impacts.

Research objectives

In this scoping review, the objectives are to collate published academic literature/papers on health professionals' knowledge, attitudes, perceptions and practices regarding climate change and health impacts. We aim to map the findings by categorizing papers according to their topic and context information, establish an open database of relevant literature, and provide a thematic analysis on the content. The preparedness of health professionals on climate change actions will be assessed through the gaps in their knowledge, attitudes, perceptions and practices. The organizational, national and international hurdles and challenges health professionals face in realizing their full potential will be identified.

The specific objectives of this study include:

- providing an overview of existing peer-reviewed literature over time about the knowledge, attitudes, perceptions and practices of health professionals regarding climate change and its health impacts;
- establishing an open database of categorized literature regarding climate change and health professionals' preparedness;
- making recommendations on the roles of health professionals in climate change and potential areas for future research.

METHOD

Patient and Public Involvement

This is a review study and there is no patient or public involvement.

Scoping review methodology

The aim of systematic scoping reviews is to rapidly synthesize "*evidence on crucial concepts associated with broad research topics in addition to identifying the central sources and forms of*

evidence available".[12] While methodological frameworks developed by Arksey and O'Malley (2005) and enhanced by Levac et al. (2010)[12 13] allow for more standardization, scoping review methods "*remain flexible to enable clarification of concepts and research questions following familiarization with the literature*". [14]

Systematic scoping reviews incorporate different study types and designs. It goes beyond answering questions about intervention effectiveness. Rigorous and systematic methods apply to demonstrate credible evidence for synthesizing knowledge. This is beneficial when a shortage of evidence prevents conduct of systematic reviews, and when there exists substantial diversity in approaches to the topic.[13]

Undertaking a systematic scoping review will allow the researchers to explore extensively the academic literature on the health professional's knowledge, attitudes, perceptions, and practices regarding climate change and health impacts and the challenges they face.

Protocol Design

The review will apply the methodological approach proposed by Arksey and O'Malley (2005) and Levac et al. (2010).[12 13] They delineated a six-stage framework for operating a scoping review: (1) identifying the research gap and the questions, (2) identifying relevant literature, (3) assessment and selection of studies, (4) charting and presenting the data, (5) collating, summarizing and reporting findings and (6) external consultation with relevant stakeholders.[12]

Stage 1: Identifying the research question

Climate change poses serious threats to population health and health professionals should play critical roles in combating the health risks. While some members of the health community are highly aware of the issues, we do not know how the health community more generally perceives this problem and what actions it prioritizes, illustrating an evidence gap. Therefore, we developed our specific research questions (Table 1).

Table 1 Research questions for the scoping review on 'climate change and health professionals'

Research questions	
1. What health professional roles have been studied regarding the health impacts of climate change?	Doctors/physicians, Public health professionals, Nurses, General practitioners, administrators, educators, Other health professionals
2. What is the geographical origin and focus of the publications?*	▸ Africa ▸ the Americas ▸ South-East Asia ▸ Europe ▸ the Eastern Mediterranean ▸ the Western Pacific
3. What types of literature are published on climate change and health professionals?	▸ Original research ▸ Review

	▸ Commentary/opinion/letter/view point/editorial ▸ Protocol
4. With what institutions and professions are corresponding authors affiliated?	▸ Country ▸ Institution ▸Profession
5. How do health professionals know about climate change and its health risk?	▸ Knowledge, attitudes, and perceptions
6. How do health professionals take actions in response to climate change and health risk?	▸ Mitigation (renewable energy streams, greening health sector, etc.) ▸ Adaptation (risk and vulnerability assessment, research into harms and risk reduction, education and training, etc.)
7. What hurdles do health professionals face in taking actions?	▸International ▸National ▸Organizational

* Categorization of regions by the World Health Organization

Stage 2: Identifying relevant studies

Relevant studies will be identified from MEDLINE/PubMed, Web of Science, Scopus, and Embase. The search strategy will include terms broad enough to cover all areas of climate change and health professionals, including Medical Subject Headings (MeSH) terms, subject headings and keywords applied to identify articles. The search strategy in the different databases will be reviewed by a Sun Yat-Sen University medical librarian.

The search strategy will be built based on the keywords demonstrated in Table 2. The terms "preparedness" and "challenge" will not be included in order to ensure the broadness of the captured literature. A preliminary search identified the earliest relevant study published in 2006. In the scoping review, we will wind five years back to 2002. To capture as many relevant studies as possible, the search strategy will allow both MeSH terms and free text.

Table 2 Search terms for the scoping review on 'climate change and health professional'

Climate change-related terms	Health professionals related terms	Date of publication
Climate change Climate variability Global warming Greenhouse effect/Greenhouse gas emissions(GHGE) Extreme weather/ Heat wave/ High temperature/ Drought/ Flooding	Health/ Medical/ Clinic/ Public health/ Healthcare professional/ worker/ technician/ technologist/ staff/ practitioner/ officer/ Assistant/ student Physician/ Physician Assistant General practitioner/ Nurse/ Doctor/ Intern Internist/ Surgeon/ psychiatrist/ Pediatrician/ Psychologist/ Endocrinologist/ Dentist/ odontologist/ obstetricians/ gynaecologists	Since 2002

Search syntaxes The key search terms of this study will be adapted to the requirements of different databases. The detailed search syntaxes are adapted from the review conducted by Osama T, et al. 2018.[15] and outlined in Table 3.

Table 3 Search strategy syntax for different databases

Database	Search strategy syntax
PubMed	(climate change [Title/Abstract] OR climate variability [Title/Abstract] OR global warming [Title/Abstract] OR greenhouse effect [Title/Abstract] OR GHGE [Title/Abstract] OR Extreme weather [Title/Abstract] OR Heat wave [Title/Abstract] OR High temperature [Title/Abstract] OR Drought [Title/Abstract] OR Flooding [Title/Abstract]) AND ((Health [All Fields] OR Medical [All Fields] OR Clinic [All Fields] OR Public health [All Fields] OR Healthcare [All Fields] OR Health care [All Fields]) AND (Professional [All Fields] OR worker [All Fields] OR technician [All Fields] OR technologist [All Fields] OR staff [All Fields] OR practitioner [All Fields] OR officer [All Fields] OR Assistant [All Fields] OR student [All Fields]) OR Physician [All Fields] OR Physician Assistant [All Fields] OR General practitioner [All Fields] OR General doctor [All Fields] OR Nurse [All Fields] OR Doctor [All Fields] OR Intern [All Fields] OR Internist [All Fields] OR Surgeon [All Fields] OR Pediatrician [All Fields] OR Psychiatrist [All Fields] OR Psychologist [All Fields] OR Endocrinologist [All Fields] OR Dentist [All Fields] OR Odontologist [All Fields]) AND (2002/01/01 [PDAT]: [PDAT])
Web of Science	TI=(climate change OR climate variability OR global warming OR greenhouse effect OR GHGE OR Extreme weather OR Heat wave OR High temperature OR Drought OR Flooding) AND TS=((Health OR Medical OR Clinic OR Public health OR Healthcare OR Health care) AND (Professional OR worker OR technician OR technologist OR staff OR practitioner OR officer OR Assistant OR student) OR Physician OR Physician Assistant OR General practitioner OR General doctor OR Nurse OR Doctor OR Intern OR Internist OR Surgeon OR Psychiatrist OR Pediatrician OR Psychologist OR Endocrinologist OR Dentist OR Odontologist) AND TIME SPAN=(2002-)
Scopus	(TITLE-ABS-KEY ("climate change" OR "climate variability" OR "global warming" OR "greenhouse effect" OR "extreme weather" OR "heat wave" OR drought OR flooding) AND (TITLE-ABS-KEY (health OR medical OR "public health" OR healthcare OR clinic) AND TITLE-ABS-KEY ((professional OR worker OR staff OR practitioner OR technician OR technologist) OR doctor OR nurse OR physician OR intern OR internist OR surgeon OR Pediatrician OR psychiatrist OR psychologist OR endocrinologist OR dentist OR odontologist))) AND (PUBYEAR > 2001)
Embase	('(climate change':ti,ab,kw OR 'climate variability':ti,ab,kw OR 'global warming':ti,ab,kw OR 'greenhouse effect':ti,ab,kw OR 'ghge':ti,ab,kw OR 'extreme weather':ti,ab,kw OR 'heat wave':ti,ab,kw OR 'high temperature':ti,ab,kw OR 'drought':ti,ab,kw OR 'flooding)':ti,ab,kw)

	AND (('((health':ti,ab,kw OR 'medical':ti,ab,kw OR 'clinic':ti,ab,kw OR 'public health':ti,ab,kw OR 'healthcare':ti,ab,kw OR 'health care)':ti,ab,kw) AND '(professional':ti,ab,kw OR 'worker':ti,ab,kw OR 'technician':ti,ab,kw OR 'technologist':ti,ab,kw OR 'staff':ti,ab,kw OR 'practitioner':ti,ab,kw OR 'officer':ti,ab,kw OR 'assistant':ti,ab,kw OR 'student)':ti,ab,kw OR 'physician':ti,ab,kw OR 'physician assistant':ti,ab,kw OR 'general practitioner':ti,ab,kw OR 'general doctor':ti,ab,kw OR 'nurse':ti,ab,kw OR 'doctor':ti,ab,kw OR 'intern':ti,ab,kw OR 'internist':ti,ab,kw OR 'surgeon':ti,ab,kw OR 'Pediatrician':ti,ab,kw OR 'psychiatrist':ti,ab,kw OR 'psychologist':ti,ab,kw OR 'endocrinologist':ti,ab,kw OR 'dentist':ti,ab,kw OR 'odontologist))':ti,ab,kw) AND [2002-]/py

MeSH, Medical Subject Headings.

Stage 3: Study Selection and Eligibility Criteria

We will use the EndNote software to remove duplicates of references searched by our research team.

The review process includes two stages: the first stage will screen titles and abstracts in English and the second stage will screen full-text in English and Chinese. Two independent reviewers will screen titles, keywords and abstracts of papers as recommended by Levac et al[13] based on the inclusion and exclusion criteria determined by the research team. Table 4 showed inclusion and exclusion criteria for the selection of articles, which was adapted from Osama T. etc, 2018 [15]. Those that meet all of the eligibility criteria of inclusion will be subjected to full-text reading. Due to resource restrictions, we will not review the full-text of articles published in a language other than English or Chinese unless their volume accounts for more than 20% of the identified abstracts. The two primary reviewers will resolve inconsistency in study eligibility, if exists, through discussions, before a third reviewer will be called upon to assist in the paper selection process. The selection process including exclusion reasons will be recorded using a PRISMA flow diagram to ensure replicability and transparency.

Stage 3 will be an iterative process, incorporating repeated attempts in search of the literature, adjustment of search strategies and selection of papers.[13]

Table 4 Inclusion and exclusion criteria for the selection of articles

Inclusion criteria	Exclusion criteria
• Peer-reviewed articles without restriction on type of publications, including original quantitative and qualitative studies, reviews, viewpoints, editorials, and commentaries. • Indexed in MEDLINE/PubMed, Web of Science, Scopus, and Embase databases • Articles published since 2002 • Focus on health professionals' roles in climate change	• Book chapters and grey literature (such as, conference proceedings, dissertations, reports, etc.).

- Publications in English and Chinese
- No restriction to geographical origin or population

Stage 4: Charting the data

A data charting form will be developed to guide data extraction from the eligible papers, including author, publication date, study type, study characteristics (location, climate change type, institutional setting [e.g. hospital, community health center, disease control and prevention center, medical college/university]), health professional characteristics, their knowledge, perception, behavior and action details on climate change (age, gender, profession, interventions and measures, views and visions, willingness to act, resources support), and hurdles and challenges identified. The charting form will be reviewed and discussed by the research team prior to the implementation to ensure comprehensiveness and completeness.

The review will map the climate change and health professionals' knowledge, perceptions and practices. Two reviewers will conduct data extraction independently. The two forms will then be compared and reconciled through discussions. If necessary, a third reviewer will be involved before a single form containing the required data is finalized.

Further, a qualitative thematic analysis approach will be applied to categorize and present the key themes in our data. This is a common approach for scoping reviews. It involves coding the contents in the literature, identifying common themes across the literature, and synthesizing the logic link across the identified themes.

Stage 5: Collating, summarizing and reporting results

Systematic scoping review studies provide an overview on a broad range of aspects of studies.[12] Usually, the results will include a numerical synopsis of the amount and type of eligible studies and a narrative synthesis of the contents of included studies. We will develop a matrix framework for reviewing different aspects of the studies. For example, the roles of health professionals can be identified from micro-, meso- and macro-levels.[10 16] Under each level, there are different perceptions and actions.

The authors will discuss practice and policy implications of the findings, as well as the need for further studies in the future.[13] To ensure a robust and holistic analysis, all different aspects of health professionals' preparedness regarding climate change will be collected. These will include, but not limited to knowledge, attitudes, practices and behaviors, interventions and programs, development resources, and legal, organizational and financial support. It's believed that this method will allow us to determine the current situation of health professionals' preparedness in response to climate change, and to find the evidence gap(s) to inform the development of measures to enhance their knowledge and practice skills.

We will perform quality appraisal on the included studies using a rating framework developed by the research team based on the EQUATOR resources (www.equator-network.org/). We will make the quality rating framework and results available in the open access database. But we will not

incorporate the quality appraisal in the review report because that is not customary for a scoping review.

Stage 6: Consultation

Public health professionals, professors and experts from the School of Public Health of Peking University, the Chinese Center for Disease Control and Prevention, the Department of Primary Care & Public Health of Imperial College (UK), London Hygiene and Tropical Medicine School (UK), and George Mason University (USA) will be consulted. They will offer valuable insights that are not captured through the literature review. At least one workshop will be organized supplemented by one-on-one meetings (face-to-face and online). Our research team has close collaboration with the above institutions, and these institutions have rich experiences and extensive studies in the field of capacity building, health professionals' knowledge, perceptions and actions on climate change. We will record and incorporate the results of consultations into the review report.

Knowledge dissemination & translation

Following completion of the scoping review, health professionals' perceptions, preparedness and actions regarding climate change over the last 16 years will be determined, yielding gaps as well as important policy, practice and research recommendations. Our recommendations will be tailored to the needs of health professionals, considering approaches for engaging and empowering health professionals. The scoping findings will be communicated and disseminated through reports and publications of the review.

Health professionals can play a vital role in communication and advocacy on climate change mitigation and adaptation. It is important that health professionals comprehensively perceive and actively communicate the health impacts of climate change. If knowledge of detrimental health effects is limited to concerned scientific communities only, health protection will not be adequate. Hence, through publication and circulation of our results on academic and lay websites, the authors aspire to develop an effective dissemination strategy to publicize recommendations to enhance health professionals' engagement.

We aim to utilize the knowledge achieved from this scoping review to develop an engagement and empowerment package for health professionals which will improve their knowledge and awareness, elicit individual behavioral change and enhance their capacity.[1] We also intend for the collected evidence to support collective, high-level actions locally, nationally, and internationally in order to address this great global health challenge of a changing climate.[1]

CONCLUSION

It is important to raise the awareness of and empower the health professionals in tackling climate change and its health risks. Around the world, we do not know about health professionals' engagement in mitigation activities or their preparedness to address the challenges of climate change. The findings of the review will enable the development of effective interventional measures and tools on the health impacts of climate change that will enhance the health professionals' engagement to address this global challenge.

ETHICS AND DISSEMINATION

No ethical approval is required for this literature-based study.

We will build an open access database of the identified literature, which will serve as a useful source of information for practitioners and researchers working on this topic. It will be updated over time and offer a comprehensive and long-term overview of the published literature on this topic. The findings will be disseminated through peer-reviewed journals, conferences at various levels, and reports available to the general public.

CONTRIBUTORS

LPY wrote the first draft of the paper and initiated the project and data collection. CJL and CRH advised on study design, study methods and revised the draft paper. JJH and DP advised on study methods and revised the draft paper. All authors approved the final version of the paper.

COMPETING INTERESTS None declared.

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PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	3
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	4-5
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4-5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	6
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	6-7
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	8
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	8-9
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	8-9
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	NA
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	NA
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	9-10

PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	NA
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	9-10
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	NA
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	NA
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	NA
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	NA
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	NA
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	NA
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	NA
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	NA
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	NA
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	11
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	11