The Journal of Climate Change and Health 3 (2021) 100045

Contents lists available at ScienceDirect

The Journal of Climate Change and Health

journal homepage: www.elsevier.com/joclim

Review

# Health impact assessment and climate change: A scoping review

Priska Ammann[a,b,*], Dominik Dietler[a,b], Mirko S. Winkler[a,b]

[a] Swiss Tropical and Public Health Institute, P.O. Box, CH-4002 Basel, Switzerland
[b] University of Basel, P.O. Box, CH-4003 Basel, Switzerland

ARTICLE INFO

*Article History:*
Received 6 July 2021
Accepted 29 August 2021
Available online 2 September 2021

*Keywords:*
Adaptation
Climate change
Health impact assessment
Health impact evaluation
Mitigation
Scoping review

ABSTRACT

Climate change has various adverse impacts on public health, ranging from heat-related illness to an increased risk of undernutrition in low-income countries. Health impact assessment (HIA) has been advocated as a valuable tool to systematically identify and quantify the effects of climate change on public health and to inform and evaluate the impact of disease-specific adaptation measures as well as health co-benefits of mitigation measures.

We conducted a scoping review to map out peer-reviewed literature on HIA in the context of climate change. Web of Science, Scopus and PubMed were searched without language or time restriction. Publications were included in the full text screening that presented or discussed the application of HIA for investigating health impacts of climate change, or associated adaptation and mitigation measures.

In total, 76 peer-reviewed publications from 26 countries were included and characterized. There was a paucity of studies on HIA in the context of climate change from low- and middle-income countries. The most investigated climate change effects were related to temperature and air-pollution. Consequently, associated health impacts, such as respiratory or cardiovascular morbidity and mortality, were examined most frequently. Research-driven HIAs with a quantitative methodological approach were the predominant choice to assess health impacts of climate change. Only one in five publications applied a classical step-by-step HIA approach.

While quantitative assessment of health impacts associated with climate change seems to be a well established field of research, the few publications applying a step-by-step HIA approach to systematically anticipate potential health impacts of climate change in a given context point at a missed opportunity for strengthening intersectoral collaboration to maximize health (co-) benefits of climate mitigation and adaptation measures. To promote the use of step-by-step HIA in regions that are most affected by climate change, HIA teaching and training efforts are urgently needed.



## 1. Introduction

Global climate change can affect human health through a myriad of direct and indirect pathways, thereby rendering the identification and assessment of health effects due to climate change exceedingly challenging and complex [1,2]. The vast majority of anticipated health impacts of climate change are negative and predicted to outweigh by far potential positive health effects (e.g. lower health risks from extreme cold) worldwide [3,4]. Since climate change will exacerbate existing health problems, populations' vulnerability to climate change and associated health impacts will largely depend on the baseline health status of populations as well as socio-economic, ecological and political factors [1,5,6]. Hence, the burden of morbidity and mortality due to climate change will be unevenly distributed, with a disproportionate burden falling on disadvantaged population groups, such as people with pre-existing illnesses and communities living in poverty as well as People of color [5-8].

In response to the many health challenges posed by global climate change, national, regional and local adaptation and mitigation measures are needed that address potential health impacts [9,10]. Furthermore, most climate change mitigation measures aiming to curb greenhouse gas emissions have considerable health co-benefits [11,12]. Since climate change affects every sector of society, and the management of health impacts requires actors across government levels, it is crucial to include a wide range of different stakeholders in decision-making processes around climate change-related mitigation and adaptation measures. Hence, there is a need to actively promote intersectoral, multi-stakeholder approaches in climate change assessment, adaptation and mitigation processes [10,13].

* Corresponding author at: Swiss Tropical and Public Health Institute, Socinstrasse 57, 4051 Basel, Switzerland
*E-mail address:* priska.ammann@swisstph.ch (P. Ammann).

https://doi.org/10.1016/j.joclim.2021.100045

In 1999, recognizing that human populations would be exposed to some degree of climate change, irrespective of any mitigation action that might be taken, the European Ministerial Conference on Environment and Health recommended countries promote the health impact assessment (HIA) approach in order to identify the vulnerability of populations and communities and to continuously review available mitigation and adaptation options [14]. This is in line with the Health in All Policies (HiAP) approach promoted by the World Health Organization (WHO), which aims to consider public health across policy sectors [15,16]. HIA is "a process which systematically judges the potential, and sometimes unintended, effects of a project, program, plan, policy, or strategy on the health of a population and the distribution of those effects within the population" [17]. For this purpose, HIA follows a step-by-step approach, namely (i) screening, (ii) scoping, (iii) assessment of impacts and reporting, (iv) decision-making and recommendations, and (v) evaluation, monitoring and follow-up [18,19]. HIA can be conducted as a stand-alone approach as well as integrated into other forms of impact assessments (IAs), such as environmental impact assessments (EIAs) [20]. In addition to the classical step-by-step HIA, the term HIA is used in research when examining, for instance, health impacts of policies or technological developments. However, such research-driven HIAs tend not to be linked to decision-making processes and rarely involve stakeholder participation [21,22]. While both the step-wise and research-driven HIAs have been applied to assess health impacts of climate change or climate change adaptation and mitigation strategies [23-26], step-by-step HIA has been proposed as a key methodological approach due to its inclusive and multidisciplinary nature, its holistic approach to health, and its systematic consideration of a broad range of health determinants [10,19,27-29].

The most recent review of the application of HIA in the context of climate change dates back to 2003, when Kovats and colleagues reviewed methodologies used for national and regional assessments of climate change-related health impacts [27]. In the present study, we sought to systematically map peer-reviewed publications that present on HIA in the context of climate change. The research was guided by the overarching question of whether and to what extent step-by-step HIA has been applied to systematically judge potential climate change-related health impacts and to generate evidence for appropriate adaptation and mitigation measures.

## 2. Methodology

### 2.1. Search terms and strategy

Our systematic literature search was guided by the "Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation" [30]. Relevant peer-reviewed studies were identified in three electronic databases, namely PubMed (Medline), Scopus and Web of Science (WoS), using appropriate search terms. The search terminology was developed by the first author (P.A.) in collaboration with M.S.W. More specifically, for each database, the search strings were amended to the specific features of the database, validated and adapted using a random selection of six previously identified studies on the topic of HIA and climate change, whereof three were case studies and three were methodological papers. The final search strategy was conducted in English and consisted of two search term blocks: (i) HIA and (ii) climate change-related terms. No language, time or spatial restrictions were applied for the search administered on August 21, 2020. Hence, identified articles with an English abstract, but the main text written in another language, were included. Details of the search terminology developed for each database are presented in Table A.1 (Appendix A). A review protocol was designed in advance to address the research questions, search strategy, data extraction, synthesis and analysis. The protocol was not registered.

**Table 1**
Inclusion criteria for the title and abstract and full-text screening.

| Stage of screening | Inclusion criteria |
|---|---|
| Title and abstract screening | • Peer-reviewed publication<br>• Reference to<br>(i) climate change and/or climate change-related adaptation/ mitigation plans, programs or policies<br>(ii) health impacts of climate change and/or of climate change-related adaptation/mitigation plans, programs or policies |
| Full-text screening | • Full-text retrievable with the access rights of the University of Basel<br>• Peer-reviewed publication<br>• Presents a research-driven or step-by-step health impact assessment in the context of climate change |

### 2.2. Peer-reviewed literature screening

Titles and abstracts of all records were independently screened for eligibility by two authors (P.A. and M.S.W.) using EndNote version X9.2 for data management (Thomson Reuters Corp., New York City, NY, USA) and Microsoft Excel (Microsoft Office Student and Home 2016, Microsoft Corporation, Redmond, WA, USA). Discrepancies were discussed amongst the two authors until consensus was reached. Records were de-duplicated using automatic detection in EndNote and hand curation. P.A. screened the remaining full texts with support from M.S.W.

Publications were considered eligible if they: (i) were accessible within the rights of the University of Basel; and (ii) presented a study that focused on health impacts of climate change effects, climate change adaptation or mitigation projects, plans or programs. Table 1 provides an overview of the applied inclusion criteria during the different screening stages of the scoping review. Case studies, reviews and methodological articles were included irrespective of the discussed or employed HIA method. Integrated assessments such as vulnerability assessments or environmental health impact assessments were only included if health impacts of climate change were the main focus of the article. If the topic of health and climate change was only covered partially (e.g. life cycle assessments or climate change policy analyses), the publication was excluded. Since the focus of this scoping review lies solely on peer-reviewed articles, other types of references, such as grey literature, books, book chapters, conference proceedings, editorials, commentaries and other opinion pieces, were excluded.

### 2.3. Data analysis

Based on the full-text analysis, data extraction of the remaining papers was conducted by P.A., with assistance and inputs from M.S.W. The first author (P.A.) developed the data extraction form in a Microsoft Excel spread sheet with the following variables: (i) the articles´characteristics (author, year of publication, first author's institution's country, study country, research method and study type); (ii) characteristics of the domain "HIA" (HIA as an application or topic, type of HIA, i.e. step-by-step or research-driven HIA, scale of HIA, temporal focus and geographical level of the assessment); (iii) specificities of the domain "climate change" (focus on climate change effects, adaptation or mitigation measures, and which effects of climate change were examined); and (iv) investigated health effects (health outcomes). We first examined general characteristics of all included articles, i.e. the study country, publication year and geographical scope of the HIA. In a next step, P.A. and M.S.W. studied the

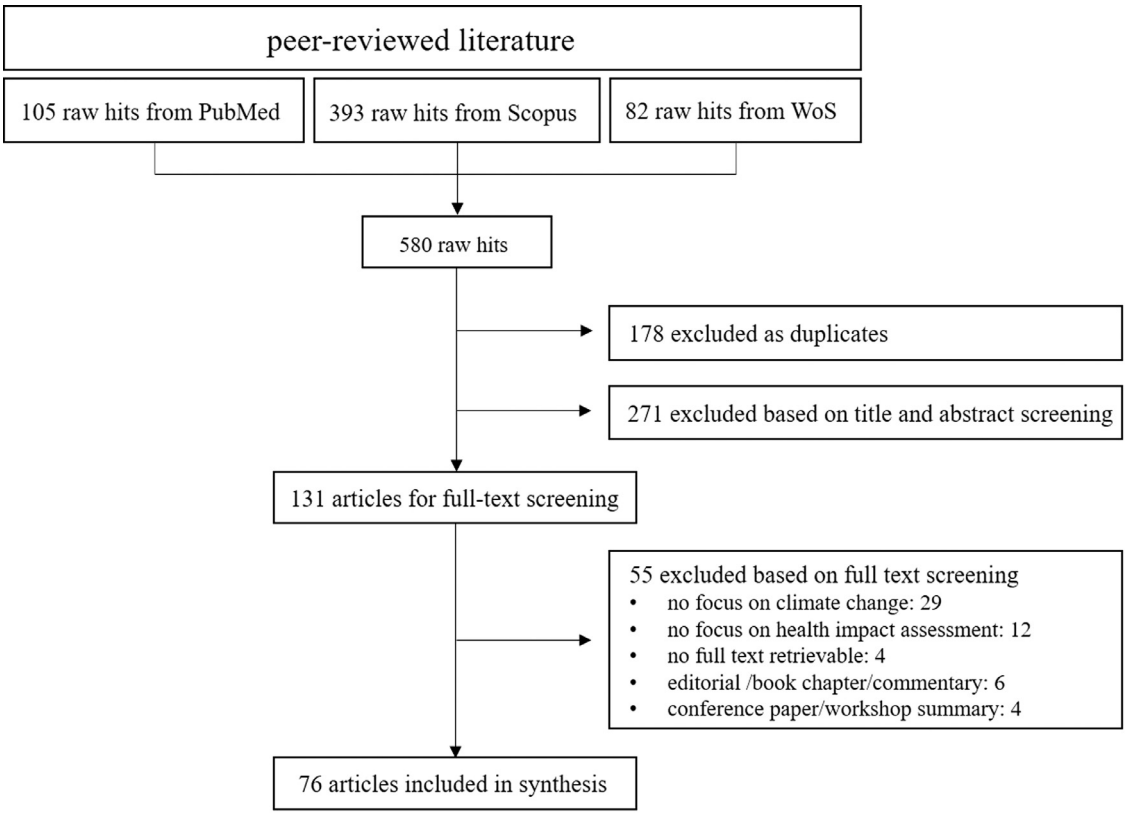


**Fig. 1.** PRISMA flow chart showing the number of articles identified in PubMed, Scopus and Web of Science (WoS), screened and included in the scoping review.

publications identified and grouped them into two categories: (i) research-driven HIA; and (ii) step-by-step HIA. The final thematic synthesis of the publications was done based on the domains of interest, namely HIA as an application or topic, methodological approaches, types of climate change effects investigated and health outcomes studied.

## 3. Results

### 3.1. Overview

A total of 580 records were identified based on PubMed (Medline), Scopus and WoS (Fig. 1). After removal of 178 duplicates, 402 unique studies remained. Subsequent to the title, abstract and full-text screening process, 76 records were included for data extraction and analysis. Of them, only one study was written in French while the rest was in English. All included publications are listed in Table A.2 (Appendix A).

### 3.2. Study country and publication year

In Fig. 2, the geographic distribution of the 76 included records is presented. Panel A shows the countries in which the studies were conducted. A total of 12 (16%) publications looked at a global or no defined geographical scope, while the remaining 64 (84%) articles examined health impacts of climate change in one or more countries. Of these country-specific studies focusing on one or several countries, 55 (86%) reported on health impacts of climate change in high- and middle-income countries, and only nine (14%) in low-income countries. Health impacts associated with climate change in Oceania (4 countries) were reported by ten (13%) out of the total of 76 articles and three (30%) of these ten publications specifically assessed health impacts of climate change in Small Island Developing States (SIDS) (3 countries). Only four (5%) studies focused on Africa (3 countries, 1 sub-Saharan Africa-specific) and three (4%) studies on Asian countries other than China (3 countries). None of the included publications reported on HIA and climate change in Latin America.

In Panel B of Fig. 2, the number of published articles per location of the first author's affiliated institution are presented. In case the first author was affiliated with multiple institutions, the country reported in the correspondence address was chosen for analysis. Most institutions ($n$ = 32, 42%) were based in Europe, followed by North America ($n$ = 21, 28%) and Australia ($n$ = 13, 17%). Only one (1%) author's leading affiliation was an institution from a low-income country (Madagascar). The first authors' affiliations comprise a wide range of institutions, including academia and research centers ($n$ = 54, 71%), governmental authorities ($n$ = 14, 18%), multilateral organizations ($n$ = 5, 7%) and private companies $n$ = 3, 4%).

The oldest identified article was published in 1997 (Fig. 3). The median number of articles published per year was five and 57 (75%) of the articles were published between 2014 and 2020, suggesting an increasing trend in peer-reviewed publications about HIA of climate change. The majority of the included studies ($n$ = 58, 76%) focused on one single country. The geographical scope of the HIA in most publications ($n$ = 26, 33%) was national (country-level), regional (sub-national level) ($n$ = 23, 32%) or local (city-level; $n$ = 25, 32%). In nine studies (12%), health impacts of climate change were examined on a global level, and eight records (11%) focused on HIA of climate change on a supranational level (multinational area or entity). A total of 13 (17%) publications included HIAs on more than one geographical level, which were counted individually in the analysis. Hence, frequencies exceed the total of 76 studies.

### 3.3. Study and HIA characteristics

We examined the approach with which the included studies ($n$ = 76) covered the topic of, or assessed, health impacts of climate change, adaptation or mitigation measures (Fig. 4). In 57 (75%) of the

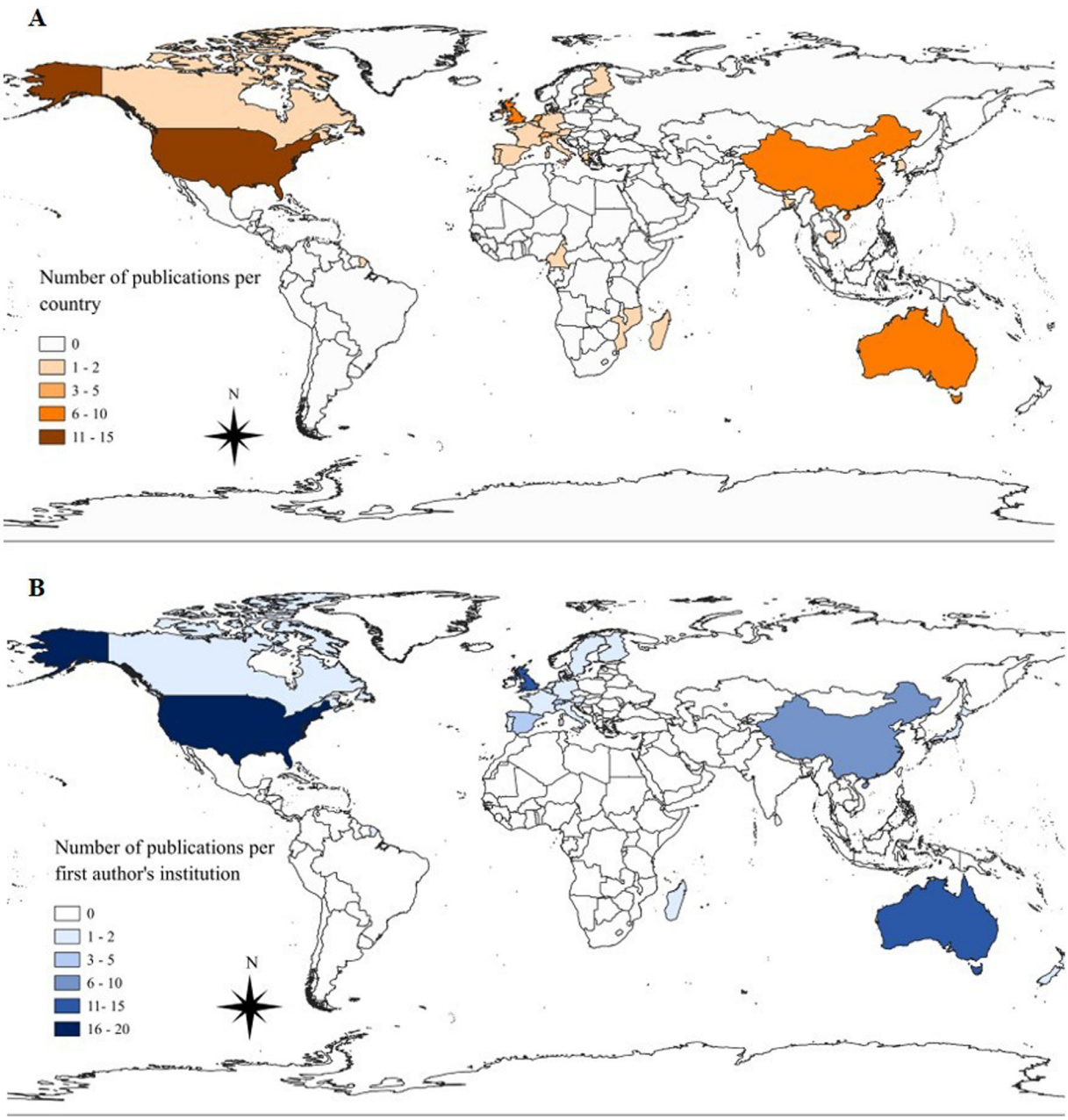


**Fig. 2.** Geographical distribution of included articles ($n$ = 76) by study country **(A)**, and by location of the publication's first author's institution **(B)**.

included publications, HIA was applied to assess certain health impacts of climate change ("HIA as an application" domain, Fig. 4). Of these, the vast majority were research-driven HIAs ($n$ = 46, 81%). HIA of climate change was discussed ("HIA as a topic" domain, Fig. 4) in a quarter of identified articles ($n$ = 19, 25%), and five (26%) of these 19 studies covered the step-by-step HIA approach as a topic. A total of 60 publications (79%) focused on a research-driven HIA framework, while only 16 out of the 76 included studies (21%) focused on the step-by-step HIA approach. Qualitative methodological approaches were used in 13 (81%) of these step-by-step HIAs, whereas 46 (77%) of research-driven HIAs applied quantitative methodological approaches.

### 3.4. Climate change effects, adaptation and mitigation measures

Most articles reported on the health impacts of climate change effects ($n$ = 44, 58%), while health impacts of climate change mitigation and adaptation measures were addressed in 31 (41%) and 12 studies (16%), respectively (Fig. 5, Panel A). Only 20 publications (26%) focused on more than one climate change effect or related adaptation and mitigation measures. Of these 20 publications, 6 (30%) followed the step-by-step HIA approach. Most articles ($n$ = 50, 66%) reported on the health effects of changing temperature patterns, i.e. rising temperatures, extreme heat or cold (Fig. 5, Panel B). With 44 studies (58%), climate change-related air pollution (i.e. air pollution under climate change, and co-benefits or trade-offs of air pollution and climate change mitigation measures) was the second most investigated climate change effect. Similarly, adaptation and mitigation measures were most investigated in the context of climate change-related temperature effects and air pollution, and mainly focused on policies in the energy ($n$ = 16, 21%), transportation ($n$ = 13, 17%), or infrastructure and urban planning ($n$ = 13, 17%) sector. A more detailed overview of the studied adaptation and mitigation measures is presented in Table B.1 (Appendix B). Most ($n$ = 43, 93%) of the 46 research-driven articles that applied a quantitative methodology to

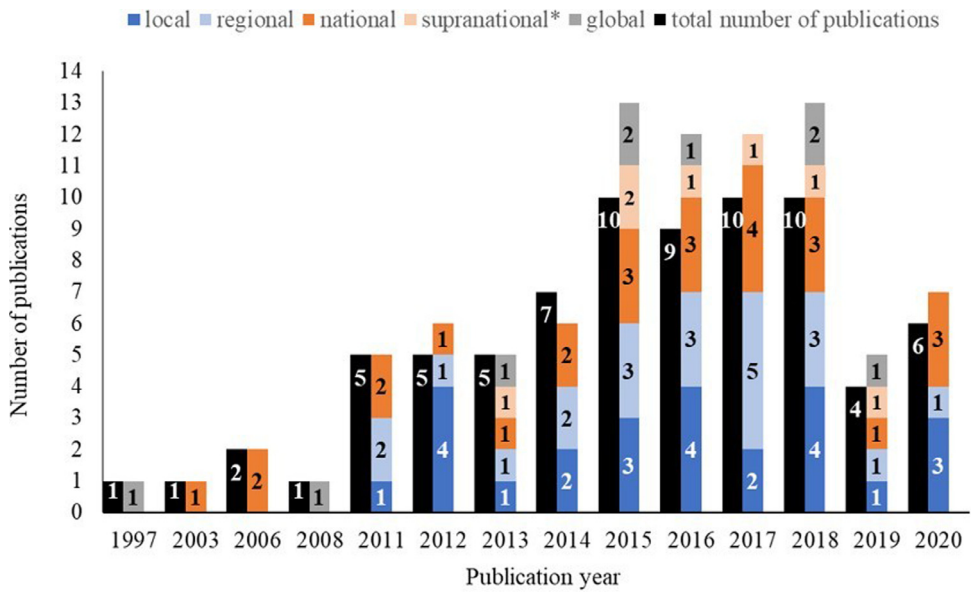


**Fig. 3.** Included articles ($n$ = 76) by year of publication and geographical scope of the HIA. Some publications included multiple geographical levels, which were counted separately. *Supranational: supranational entity or area, such as the European Union or sub-Saharan Africa.

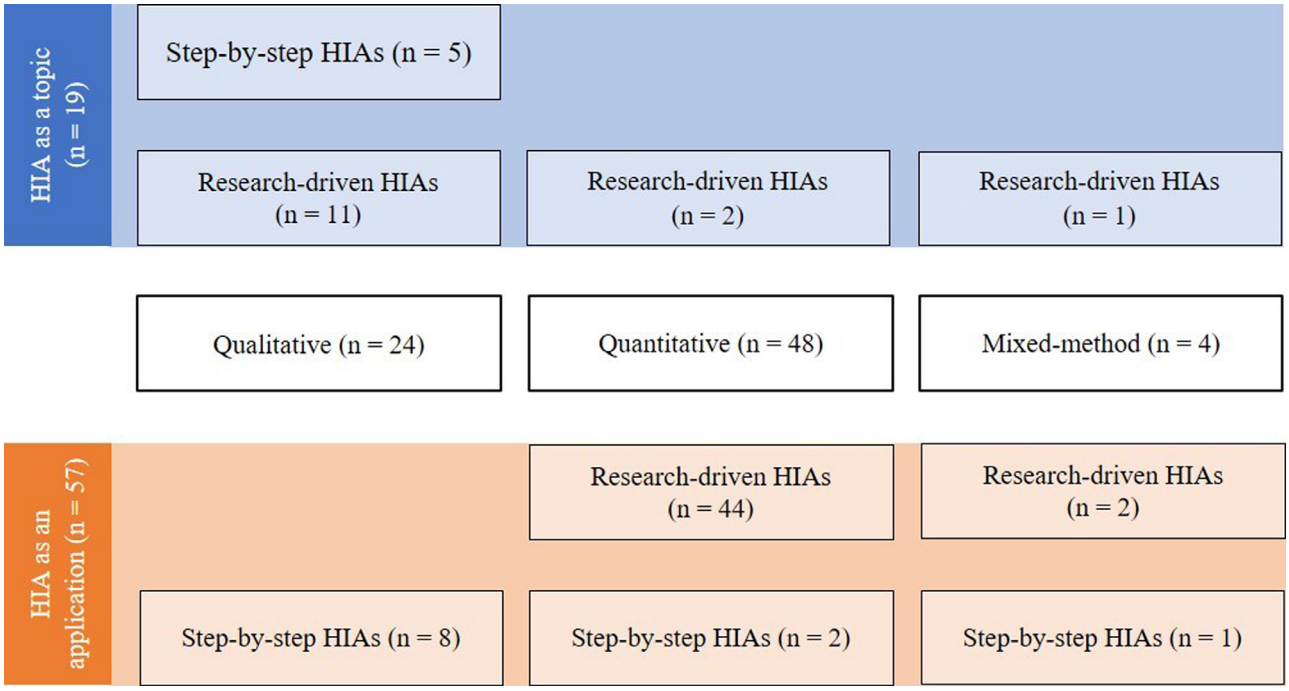


**Fig. 4.** Overview of the general study characterization of step-by-step and research-driven HIAs. Publications were grouped by study focus as either "HIA as a topic" (theoretical discussion of HIA in the context of climate change) or "HIA as an application" (assessment of health impacts of climate change, adaptation or mitigation actions). In addition, articles were categorized based on their methodological approaches (qualitative, quantitative or mixed-method).

assess health impacts of climate change solely investigated temperature effects and/or climate change-related air pollution. Similarly, the majority ($n$ = 15, 93%) of the 16 HIA publications following the step-by-step approach studied impacts of temperature changes, amongst other climate change effects.

### 3.5. Health impacts studied

As depicted in Fig. 6, a total of 12 categories of health outcomes were reported in the 76 included HIA studies. The majority of the included publications ($n$ = 48, 63%) investigated more than one health outcome, ranging from two to six. Of the assessed health impacts, respiratory and cardiovascular diseases associated with air pollution or extreme temperatures were the most studied health outcomes, with 29 (38%) and 26 (34%) publications, respectively (Fig. 6). In addition, unspecified air pollution- and temperature-related health outcomes (i.e. hospitalization and premature death rates) were investigated in 18% ($n$ = 14) and 14% ($n$ = 11) of included articles. Out of the 16 step-by-step HIA publications, three did not specify any health outcomes. All of the remaining 13 articles (81%) examined more than one health outcome, and only two of these 13 studies (13%) focused exclusively on air-pollution or temperature-related health outcomes. The most frequently assessed health outcomes in step-by-step HIAs were injuries and accidents ($n$ = 6, 38%), followed

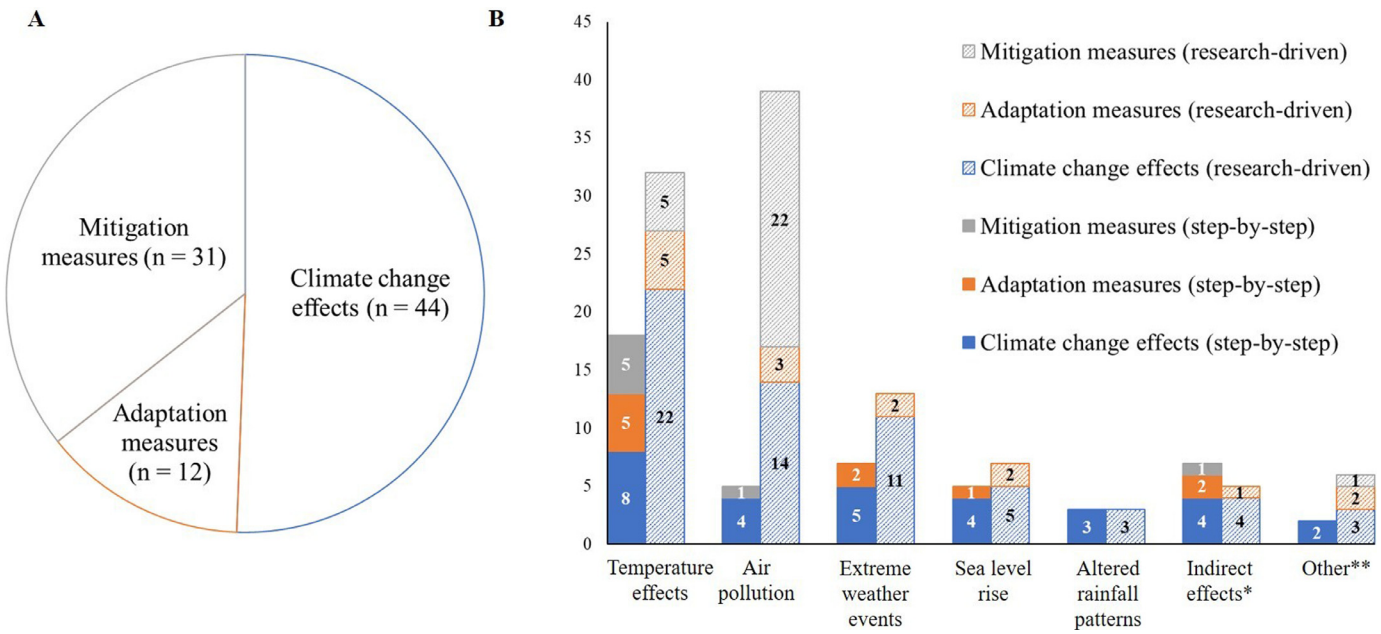


**Fig. 5.** Number of included studies ($n$ = 76) reporting on health impacts of climate change, or related adaptation or mitigation measures **(A)**, and main categories of climate change effects studied in research-driven and step-by-step HIA publications **(B)**. If studies explored climate change effects as well as mitigation and/or adaptation measures, or focused on more than one climate change effects, they were counted separately in each category. Hence, frequencies may exceed the total of 76 included studies. *Indirect effects: food production, water quality and socio-economic effects; **Other: ocean acidity/salinity, dust and UV-radiation.

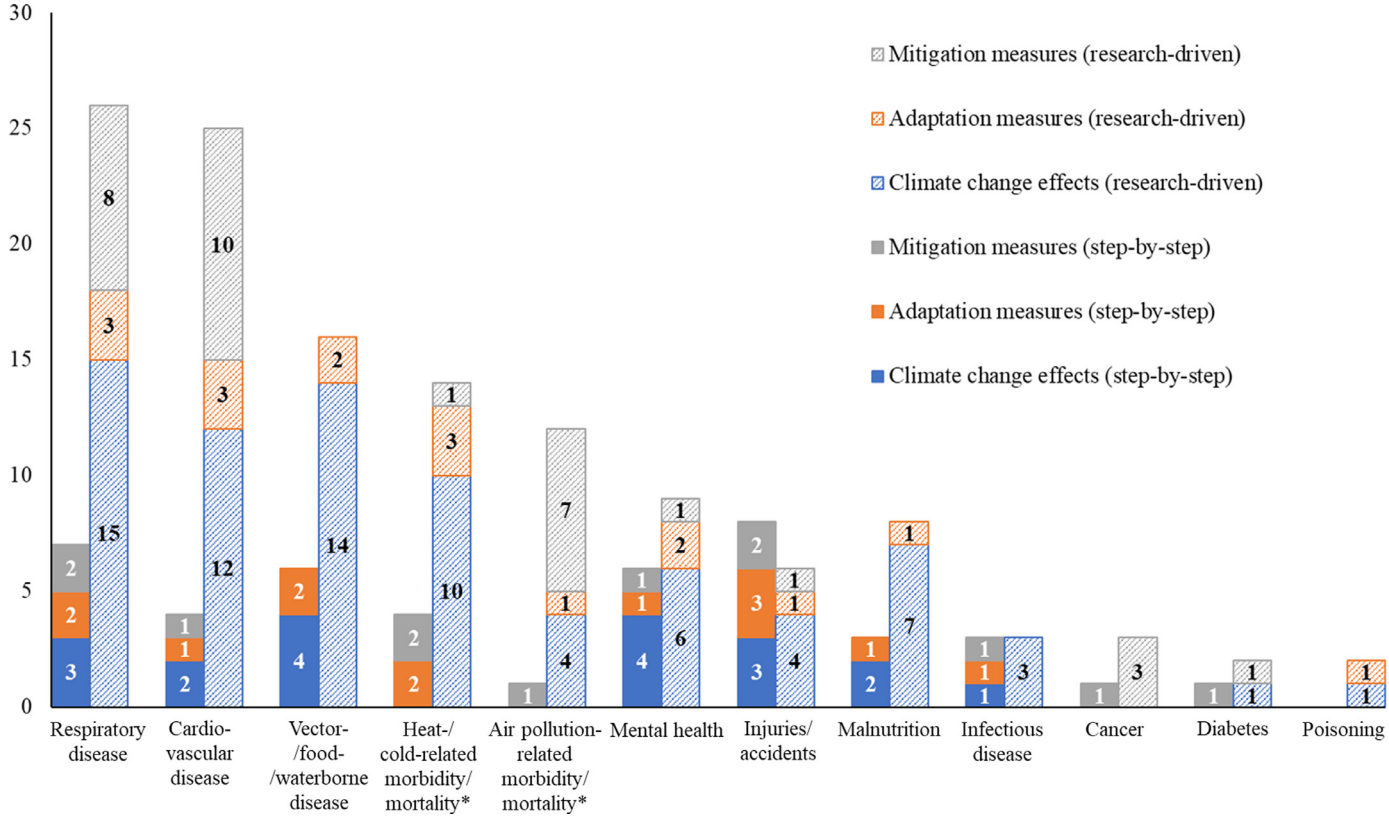


**Fig. 6.** Investigated health outcomes of climate change effects, adaptation and mitigation measures studied in the 76 identified HIA articles. Numbers indicate the total of reporting articles. As some studies examine multiple health outcomes, frequencies exceed the total number of included publications. *The categories heat- and cold-related as well as air pollution-related morbidity/mortality consist of hospitalizations and premature deaths due to unspecified health conditions related to these exposures.

by mental health, vector-/food-/waterborne and respiratory disease with five publications each (31%). In comparison, of the 60 research-driven HIA articles, 23 (38%) investigated one single health outcome, and 36 publications (60%) solely investigated health outcomes associated with air pollution, heat or cold, including respiratory and cardiovascular disease. Both research-driven and step-by-step HIAs examined health outcomes of climate change effects, adaptation, and mitigation measures.

## 4. Discussion

In the present scoping review, 76 peer-reviewed publications about HIA and climate change from 26 countries in Africa, Europe, Asia, North America and Oceania were included and analysed. Few HIAs examined health impacts in low-income countries. The vast majority of articles covered research-driven HIAs and employed a quantitative methodological approach to assess health impacts of climate change or of climate change adaptation and mitigation. The most investigated climate change effects were related to air-pollution and changes in temperature. Hence, respiratory and cardiovascular disease as well as temperature- and air pollution-related morbidity and mortality were by far the most frequently examined health impacts. In comparison, other climate effects, such as altered rainfall patterns or indirect hazards and their associated health impacts were rarely mentioned.

### 4.1. Health outcomes

According to the report of the Intergovernmental Panel on Climate Change (IPCC) from 2014, climate change will cause major changes in ill-health through a broad variety of pathways, including increased risk of morbidity and mortality due to heat waves and fires, undernutrition in poor regions, reduced labour productivity in vulnerable populations, as well as greater risks of food- and waterborne diseases [1]. However, the identified literature on HIA in the context of climate change strongly focuses on temperature changes and air pollution and associated respiratory and cardiovascular health outcomes. This pattern was also seen in a recent review of 15,914 publications on the broader literature on climate change and health [31]. The heavy emphasis on these two health outcomes can be explained, at least partially, by their respective contribution to the global burden of disease. Air pollution is the largest environmental risk factor for ill health and mortality globally, causing roughly 7 million premature deaths annually [1,32]. Rising temperatures and more frequent extreme heat events are a major threat for human health, particularly in urban settlements, as cities tend to experience higher temperatures than surrounding rural areas [1,32,33]. Less developed regions are projected to host 83 per cent of the world's urban population by 2050 with an increasing share of the more vulnerable elderly population, and will therefore face the challenges posed by both climate change and rapid urbanization [34,35]. While the consideration of these major climate hazards is promising, the negligence of the more indirect impacts of climate change, as well as the predominant focus of the scientific literature on HIA in the context of climate change in high-income countries, is worrisome for health equity. Indeed, the high dependence of the world's poor on ecosystem goods and services will further increase the health burden from climate change, highlighting the need for more HIAs investigating health effects of climate change that are of particular relevance for low-income countries and vulnerable populations [6,9,36].

### 4.2. Methodology, subject and scope of HIAs

In the current scoping review, only one in five studies applied or discussed the step-by-step HIA approach in the context of climate change. Those publications generally considered a more diverse set of climate change effects and health outcomes than the research-driven HIAs identified. This indicates a missed opportunity to develop and apply different methodological approaches to holistically investigate multiple potential health outcomes of climate change. Given the complexity of climate change, research-driven HIAs add valuable knowledge about specific health outcomes by assessing exposure-response relationships under a changing climate and provide relevant results for decision-makers [37-39]. However, they tend not to consider wider determinants of health, any potential co-benefits or unintended impacts of climate policies, the strengthening of stakeholder involvement or the reduction of health inequities [16]. In contrast, some key components of step-by-step HIAs are stakeholder participation in the assessment and decision-making process, and a comprehensive definition of health [17]. As climate change affects human health in a myriad of direct and indirect pathways and exacerbates existing inequalities and health problems, these guiding principles are pivotal [10,17]. Hence, the step-by-step HIA approach has been proposed as a fundamental methodological approach for evaluating health impacts of climate change and associated adaptation and mitigation measures [10,26,28]. Yet, step-by-step HIAs have typically been applied to projects, plans or policies, and hence may require different methodological approaches with regard to climate change [28,40]. Therefore, it is crucial that beyond promoting the application of HIA in the context of climate change, experiences from these assessments are shared with the wider scientific community.

In our scoping review, most articles that investigated climate change adaptation or mitigation measures focused on policies in the energy, transportation or infrastructure and urban planning sector, and mainly in view of climate change-related air pollution and temperature effects. However, climate policies in all sectors can have significant impacts on population health and well-being [41-43]. By means of step-by-step HIA, effects of adaptation and mitigation measures on health could be investigated across public sectors, and synergies between sustainability and health promotion strengthened [43-45]. Furthermore, step-by-step HIAs can aid in assessing co-benefits, trade-offs or cross-border effects of climate mitigation policies [10,46]. For instance, the promotion of biofuels as an alternative energy source directly impacts global biofuel crop and food production and can therefore increase poverty and deforestation [47]. Thus, in order to enhance intersectoral collaboration in climate policy-making, the HIA community is encouraged to incorporate and specifically address HIA of climate change in capacity building, research and practice [10,17].

### 4.3. Global perspective on climate change and health impact research

Our scoping review revealed a dearth of health impact studies conducted in low- and middle-income countries (LMICs) despite their being the most afflicted by global climate change [1,2,48]. None of the included articles were conducted in Latin America, and only one author's leading affiliation was an institution based in a low-income country. There are several potential explanations why Latin America and LMICs in general are underrepresented in our review. First, the application of HIA in Latin America and sub-Saharan Africa is reportedly not common practice, even for plans, projects or programs in areas beyond climate change [27,49-51]. Second, we did not include grey literature and conducted the literature search in English. Although we did not actively exclude publications written in other languages than English, restricting the search terms to English likely increased the chance that some publications were missed in the reviewing process.

Nevertheless, the disparity between where most HIAs were carried out, and the expected impacts of global climate change on health and well-being is striking. However, in view of similar findings in climate change and health research [31], as well as the 10/90 gap in health research funding [52] or the 6/94 gap in HIA [53], this geographical imbalance of HIA studies in our scoping review is of little surprise. Hence, research on health impacts from global climate change should be actively promoted and supported in LMICs in order to anticipate and abate disastrous effects on health and well-being. Furthermore, HIA capacity strengthening, particularly in the context of climate change, should be intensified in LMICs for promoting its application in the most affected regions.

### 4.4. Limitations

Several limitations of our study have to be addressed. First, we did not include grey literature. Given that many HIA studies are not published in the peer-reviewed literature, it is likely that some efforts by the impact assessment community have been missed. With national governments being encouraged to conduct national HIAs of climate change [15,54], we recognize that a more comprehensive review is required that includes grey literature from governmental authorities and non-academic institutions worldwide. Second, we identified relevant articles using search terms in English. Therefore, the geographical distribution of identified studies may not fully represent current practice. Nevertheless, there are a series of reviews that have identified similar geographical patterns in impact assessment practice, even when applying a multi-lingual search strategy [53,55]. We furthermore aimed to minimize the risk of missing relevant literature by conducting our search in three widely known academic databases and by employing a variety of broad search strings adapted to each database. Lastly, since the objective of our scoping review was to map out the state of the literature in the realm of climate change and HIA, the quality of included publications was not systematically appraised. In view of the diversity of papers mapped out in our scoping review (e.g., research-driven HIA and step-by-step HIA), the identification and development of an appropriate quality appraisal tool would have been challenging. Furthermore, we feel that a critical appraisal of the quality of the papers would have added little value to the scoping review conducted.

## 5. Conclusion

Although LMICs bear the biggest health burden from climate change, the vast majority of published HIAs in the context of climate change present studies or case studies conducted in high-income countries. amongst the identified HIA publications, a narrow range of investigated climate change effects and associated health impacts is considered, which applies in particular to research-driven HIA. The recommended step-by-step HIA approach was only applied in one-fifth of the publications identified, suggesting a development opportunity for HIA research and practice. With its comprehensive approach to health, participation as a guiding principle and the systematic consideration of health equity and equality, step-by-step HIA offers an opportunity to promote health and well-being in climate change affected communities, while paying particular attention to vulnerable and marginalised groups. However, for step-by-step HIA to become common practice in countries where health impacts of climate change will be most pronounced, HIA teaching and training efforts need to be promoted with some urgency.

## Author contributions

Conceptualization, P.A. and M.S.W.; methodology, P.A. and M.S.W.; formal analysis, P.A..; writing—original draft preparation, P.A. and M.S.W.; writing—review and editing, P.A., D.D. and M.S.W.; visualization, P.A.; supervision, M.S.W.; funding acquisition, M.S.W. All authors have read and agreed to the published version of the manuscript.

## Declaration of Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.joclim.2021.100045.

## References


[1] Smith KR, Woodward A, Campbell-Lendrum D, Chadee DD, Honda Y, Liu Q, et al. Human health: impacts, adaptation, and co-benefits. In: Field CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, editors. Climate change 2014: impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change. Cambridge, United Kingdom and New York, USA: Cambridge University Press; 2014. p. 709–54.

[2] IPCC, 2012. In: Field CB, Barros VR, Stocker TF, Qin D, Dokken DJ, Ebi KL, editors. Managing the risks of extreme events and disasters to advance climate change adaptation. A special report of working groups I and II of the intergovernmental panel on climate change. Cambridge, United Kingdom and New York, USA: Cambridge University Press; 2014. p. 582.

[3] Vardoulakis S, Dear K, Hajat S, Heaviside C, Eggen B, McMichael AJ. Comparative assessment of the effects of climate change on heat-and cold-related mortality in the United Kingdom and Australia. Environ Health Perspect 2014;122(12):1285–92. doi: 10.1289/ehp.1307524.

[4] Hoegh-Guldberg O, Jacob D, Taylor M, Bindi M, Brown S, Camilloni I, et al. Impacts of 1.5 °C global warming on natural and human systems. In: Masson-Delmott V, Zhai P, Pörtner H-O, Zhou X, Gomis MI, Lonnoy E, editors. Global warming of 1.5 ° C. an ipcc special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. In Press; 2018.

[5] Core Writing Team, IPCC. In: Pachauri RK, Meyer LA, editors. Climate change 2014: synthesis report. contribution of working groups I, II and III to the fifth assessment report of the intergovernmental panel on climate change. Geneva, Switzerland: IPCC; 2014. p. 151..

[6] Patz JA, Gibbs HK, Foley JA, Rogers JV, Smith KR. Climate change and global health: quantifying a growing ethical crisis. Ecohealth 2017;4(4):397–405. doi: 10.1007/s10393-007-0141-1.

[7] World Health Organization. Fact sheet: climate change and health, 2018. https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health [accessed 6 March 2021].

[8] [ McMichael A, Campbell-Lendrum D, Kovats S, Edwards S, Wilkinson P, Wilson T, et al. Global climate change. In: Ezzati M, Lopez AD, Rodgers A, Murray CJL, editors. Comparative quantification of health risks: global and regional burden of disease due to selected major risk factors. Geneva, Switzerland: World Health Organization; 2014. p. 1543–649.

[9] Winkler MS, Röösli M, Ragettli MS, Cissé G, Müller P, Utzinger J, et al. Mitigating and adapting to climate change: a call to public health professionals. Int J Public Health 2015;60(6):631–2. doi: 10.1007/s00038-015-0722-7.

[10] Patz JA, Campbell-Lendrum D, Gibbs H, Woodruff R. Health impact assessment of global climate change: expanding on comparative risk assessment approaches for policy making. Annu Rev Public Health 2008;29:27–39. doi: 10.1146/annurev.publhealth.29.020907.090750.

[11] Cheng JJ, Berry P. Health co-benefits and risks of public health adaptation strategies to climate change: a review of current literature. Int J Public Health 2013;58(2):305–11. doi: 10.1007/s00038-012-0422-5.

[12] Yip CS, Crane G, Karnon J. Systematic review of reducing population meat consumption to reduce greenhouse gas emissions and obtain health benefits: effectiveness and models assessments. Int J Public Health 2013;58(5):683–93. doi: 10.1007/s00038-013-0484-z.

[13] Dannenberg AL, Rogerson B, Rudolph L. Optimizing the health benefits of climate change policies using health impact assessment. J Public Health Policy 2019;41(2):139–54. doi: 10.1057/s41271-019-00189-y.

[14] World Health Organization. London declaration on action in partnership. third ministerial conference on environment and health, London, 16-18 June 1999. Copenhagen, Denmark: WHO Regional Office for Europe; 1999 http://www.euro.who.int/__data/assets/pdf_file/0007/88585/E69046.pdf [accessed 23 May 2021].

[15] Fox M, Zuidema C, Bauman B, Burke T, Sheehan M. Integrating public health into climate change policy and planning: state of practice update. Int J Environ Res Public Health 2019;16(18):3232. doi: 10.3390/ijerph16183232.

[16] Dreaves HA. How Health Impact Assessments (HIAs) help us to select the public health policies most likely to maximise health gain, on the basis of best public health science. AIMS Public Health 2016;3(2):235. doi: 10.3934/publichealth.2016.2.235.

[17] Winkler MS, Viliani F, Knoblauch AM, Cave B, Divall M, Ramesh G, et al. Health impact assessment international best practice principles. Fargo, USA: International Association for Impact Assessment; 2021 Special Publication Series No.5.

[18] Harris-Roxas B, Harris E. Differing forms, differing purposes: a typology of health impact assessment. Environ Impact Assess Rev 2011;31(4):396–403. doi: 10.1016/j.eiar.2010.03.003.

[19] Brown H, Spickett J, Katscherian D. A health impact assessment framework for assessing vulnerability and adaptation planning for climate change. Int J Environ Res Public Health 2014;11(12):12896–914. doi: 10.3390/ijerph111212896.

[20] Harris-Roxas B, Harris E. Differing forms, differing purposes: a typology of health impact assessment. Environ Impact Assess Rev 2011;31(4):396–403. doi: 10.1016/j.eiar.2010.03.003.
[21] Anenberg SC, Henze DK, Lacey F, Irfan A, Kinney P, Kleiman G, Pillarisetti A. Air pollution-related health and climate benefits of clean cookstove programs in Mozambique. Environ Res Lett 2017;12(2):025006. doi: 10.1088/1748-9326/aa5557.
[22] Buekers J, Dons E, Elen B, Panis LI. Health impact model for modal shift from car use to cycling or walking in Flanders: application to two bicycle highways. J Transp Health 2015;2(4):549–62. doi: 10.1016/j.jth.2015.08.003.
[23] Casimiro E, Calheiros J, Santos FD, Kovats S. National assessment of human health effects of climate change in Portugal: approach and key findings. Environ Health Perspect 2006;114(12):1950–6. doi: 10.1289/ehp.8431.
[24] Dannenberg AL, Rogerson B, Rudolph L. Optimizing the health benefits of climate change policies using health impact assessment. J Public Health Policy 2019;41(2):139–54. doi: 10.1057/s41271-019-00189-y.
[25] Cai W, Hui J, Wang C, Zheng Y, Zhang X, Zhang Q, et al. The Lancet Countdown on PM2.5 pollution-related health impacts of China's projected carbon dioxide mitigation in the electric power generation sector under the Paris Agreement: a modelling study. Lancet Planet Health 2018;2(4):e151–61. doi: 10.1016/S2542-5196(18)30050-0.
[26] Mueller N, Rojas-Rueda D, Khreis H, Cirach M, Andrés D, Ballester J, et al. Changing the urban design of cities for health: the superblock model. Environ Int 2020;134:105132. doi: 10.1016/j.envint.2019.105132.
[27] Kovats RS, Menne B, Ahern MJ, Patz JA. National assessments of health impacts of climate change: a review. Climate change and health: risks and responses. Geneva, Switzerland: World Health Organization; 2003.
[28] Brown HL, Proust K, Spickett J, Capon A. The potential role of Health Impact Assessment in tackling the complexity of climate change adaptation for health. Health Promot J Austr 2011;22(4):48–53. doi: 10.1071/HE11448.
[29] Diallo T, Cantoreggi N, Simos J, Christie DP. Is HIA the most effective tool to assess the impact on health of climate change mitigation policies at the local level? A case study in Geneva, Switzerland. Glob Health Promot 2017;24(2):5–15. doi: 10.1177/1757975916686920.
[30] Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med 2018;169:467–73. doi: 10.7326/M18-0850.
[31] Berrang-For L, Sietsma AJ, Callaghan M, Minx JC, Scheelbeek PFD, Haddaway NR, et al. Systematic mapping of global research on climate and health: a machine learning review. Lancet Planet Health 2021;5(8):e514–25. doi: 10.1016/S2542-5196(21)00179-0.
[32] Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya K, Adair-Rohani H, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012;380(9859):2224–60. doi: 10.1016/S0140-6736(12)61766-8.
[33] Frumkin H, Frank LD, Jackson R. Urban sprawl and public health: designing, planning and building for healthy communities. Washington, DC: Island Press; 2004.
[34] Cohen B. Urbanization in developing countries: current trends, future projections, and key challenges for sustainability. Technol Soc 2006;8(1–2):63–80. doi: 10.1016/j.techsoc.2005.10.005.
[35] United nations, department of economic and social affairs, population division. world urbanization prospects: the 2018 revision (ST/ESA/SER.A/420). New York: United Nations; 2018.
[36] Kumar P, Yashiro M. The marginal poor and their dependence on ecosystem services: evidence from South Asia and Sub-Saharan Africa. In: von Braun J, Gatzweiler F, editors. Marginality. Dordrecht, Netherlands: Springer; 2014. p. 169–80.
[37] Bernard SM, Ebi KL. Comments on the process and product of the health impacts assessment component of the national assessment of the potential consequences of climate variability and change for the United States. Environ Health Perspect 2001;109(suppl 2):177–84. doi: 10.1289/ehp.109-1240664.
[38] Åström C, Orru H, Rocklöv J, Strandberg G, Ebi KL, Forsberg B. Heat-related respiratory hospital admissions in Europe in a changing climate: a health impact assessment. BMJ Open 2013;3(1):e001842 http://dx.doi.org/. doi: 10.1136/bmjopen-2012-001842.
[39] Likhvar VN, Pascal M, Markakis K, Colette A, Hauglustaine D, Valari M, et al. A multi-scale health impact assessment of air pollution over the 21st century. Sci Total Environ 2015;514:439–49. doi: 10.1016/j.scitotenv.2015.02.002.
[40] Brown H, Spickett J. Health consequence scales for use in health impact assessments of climate change. Int J Environ Res Public Health 2014;11(9):9607–20. doi: 10.3390/ijerph110909607.
[41] World Health Organization. Health in All Policies (HiAP) framework for country action, 2014. https://www.who.int/healthpromotion/hiapframework.pdf [accessed 13 March 2021].
[42] Spickett JT, Katscherian D. Health impacts of climate change in the Solomon Islands: an assessment and adaptation action plan. Glob J Health Sci 2014;6(5):261. doi: 10.5539/gjhs.v6n5p261.
[43] Machalaba C, Romanelli C, Stoett P, Baum SE, Bouley TA, Daszak P, et al. Climate change and health: transcending silos to find solutions. Ann Glob Health 2015;81(3):445–58. doi: 10.1016/j.aogh.2015.08.002.
[44] Richardson MJ, English P, Rudolph L. A health impact assessment of California's proposed cap-and-trade regulations. Am J Public Health 2012;102(9):e52–8. doi: 10.2105/AJPH.2011.300527.
[45] Spickett JT, Brown HL, Katscherian D. Adaptation strategies for health impacts of climate change in Western Australia: application of a Health Impact Assessment framework. Environ Impact Assess Rev 2011;31(3):297–300. doi: 10.1016/j.eiar.2010.07.001.
[46] Lock K., McKee M. Health impact assessment: assessing opportunities and barriers to intersectoral health improvement in an expanded European Union. J Epidemiol Community Health. 22005;59(5):356–60. https://doi.org/10.1136/jech.2004.024026.
[47] Renzaho AM, Kamara JK, Toole M. Biofuel production and its impact on food security in low and middle income countries: implications for the post-2015 sustainable development goals. Renew Sust Ener. Rev. 2017;78:503–16. doi: 10.1016/j.rser.2017.04.072.
[48] Thomas DSG, Twyman C. Equity and justice in climate change adaptation amongst natural-resource-dependent societies. Glob Environ Change Hum Policy Dimens 2015;15:115–24. doi: 10.1016/j.gloenvcha.2004.10.001.
[49] Abe KC, Miraglia SGEK. Health Impact Assessment (HIA) in Brazil and Latin America: an essential tool for projects, plans and policies. Interface (Botucatu) 2018;22(65):349–58. doi: 10.1590/1807-57622016.0802.
[50] Drewry J, Kwiatkowski R. The role of health impact assessment in advancing sustainable development in Latin America and the Caribbean. J Environ Health 2015;77(8):16–20 https://www.jstor.org/stable/26330229.
[51] Leuenberger A, Farnham A, Azevedo S, Cossa H, Dietler D, Nimako B, et al. Health impact assessment and health equity in sub-Saharan Africa: a scoping review. Environ Impact Assess Rev 2019;79:106288. doi: 10.1016/j.eiar.2019.106288.
[52] Stevens P. Diseases of poverty and the 10/90 gap. London, UK: International Policy Network; 2014 http://who.int/intellectualproperty/submissions/InternationalPolicyNetwork.pdf [accessed 13 March 2021].
[53] Erlanger TE, Krieger GR, Singer BH, Utzinger J. The 6/94 gap in health impact assessment. Environ Impact Assess Rev 2008;28:349–58. doi: 10.1016/j.eiar.2007.07.003.
[54] World Health Organization. Declaration of the sixth ministerial conference on environment and health. Copenhagen, Denmark: European Environment and Health Process (EHP) Secretariat, WHO Regional Office for Europe; 2017.
[55] Zabré HR, Dietler D, Diagbouga SP, Winkler MS. Scoping review of the inclusion of economic analysis in impact studies of natural resource extraction projects. Impact Assess Proj Apprais 2021:1–16. doi: 10.1080/14615517.2021.1910182.