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Review

Climate change and influenza: A scoping review

Morgan A. Lane[a,*], Maria Walawender[b], Jasmine Carter[b], Erik A. Brownsword[a], Taylor Landay[b], Thomas R. Gillespie[b,d], Jessica K. Fairley[a,b], Rebecca Philipsborn[b,c], Colleen S. Kraft[a,e,f]

[a] Division of Infectious Diseases, Department of Medicine Emory University, 1364 Clifton Rd., Atlanta, GA, 30322, United States of America
[b] Rollins School of Public Health, Emory University, 1519 Clifton Rd., Atlanta, GA, United States of America
[c] Department of Pediatrics, Emory University, 201 Dowman Dr., Atlanta, GA 30322, United States of America
[d] Department of Environmental Sciences, Emory University, 400 Dowman Dr., Atlanta, GA 30322, United States of America
[e] Department of Pathology and Laboratory Medicine, Emory University, 201 Dowman Dr., Atlanta, GA, 30322, United States of America
[f] Emory Healthcare, 1364 Clifton Rd., Atlanta, GA, 30322, United States of America

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ABSTRACT

Increasing evidence suggests that climate change affects the incidence of influenza, however, no reviews have evaluated this evidence across the entire transmission cycle of the disease. To bolster medical and public health systems preparedness for future annual and pandemic influenza, an understanding of how climate affects this transmission cycle is necessary. This scoping review searched the literature examining the effect of climate change on influenza until August 2020. Included articles covered research on climate effects across four thematic areas: 1) viral biology, 2) animal hosts, 3) human epidemiology, and the 4) impact of other planetary health factors on influenza (e.g., urbanization, water scarcity). The database search yielded 19,549 texts, of which 341 full texts were analyzed and 173 included. This review highlights the need to expand the geographical context and methods of research spanning the influenza transmission cycle to help determine which climatological factors affect influenza transmission and prepare for future influenza scenarios.

1. Introduction

Climate change has been altering life on this planet for decades, and its effects will continue to intensify [1]. Disruptions of and stresses to food and water systems can increase malnutrition and diarrheal disease while increased temperatures can exacerbate existing chronic conditions and lead directly to heat-related illness [2]. Altered land use coupled with changes in weather patterns, may cause vectors such as mosquitos and ticks to migrate to new places that fit their climate profile, exposing previously unaffected populations to diseases such as dengue [2]. Climate change also increases allergens in the air, promotes injuries through increasing extreme weather events, and drives large-scale patterns of human migration through environmental degradation that renders some areas unlivable [2].

As climatological factors change and humans migrate, encroach on animal habitats, and disrupt food production and delivery systems, there is also the opportunity for patterns of respiratory infections to change. Climate change creates conditions with the potential to exacerbate and increase exposure to respiratory infections [3,4], while the drivers of climate change, such as air pollution, simultaneously exacerbate health vulnerabilities and contribute to increases in respiratory infections [3,5,6]. Variations in temperature and precipitation could influence the emergence, distribution, morbidity, and mortality associated with respiratory infections. Climate factors can also have an effect on human host immune systems and human behaviors, altering susceptibility to respiratory infections [7]. Most recently, these effects have been recognized as contributing to the initiation and spread of the ongoing COVID-19 pandemic [8,9].

According to the WHO's Global Health Estimate for 2019, lower respiratory infections (LRIs) were ranked as the fourth leading cause of death globally and the second leading cause of death among low-income countries [10]. In 2016, LRIs caused over 2·37 million deaths across all age groups [11]. Influenza, a respiratory illness that also exacerbates underlying health conditions [12], is responsible for an estimated annual global burden of mortality between 290,000 – 650,000 deaths [10]. Additionally, there is growing concern about climate change increasing the potential for pandemic viruses, including influenza [13].

Because of the reach and importance of influenza, there is a substantial body of research, some of which has begun to explore the impact of climate change on various aspects of influenza and its transmission cycle. To determine possible methods of bolstering medical and public health preparedness for current and upcoming

* Corresponding author at: Morgan Lane, 1364 Clifton Rd, GG17A, Atlanta, GA 30322, United States of America.
E-mail address: morgan.a.lane@emory.edu (M.A. Lane).

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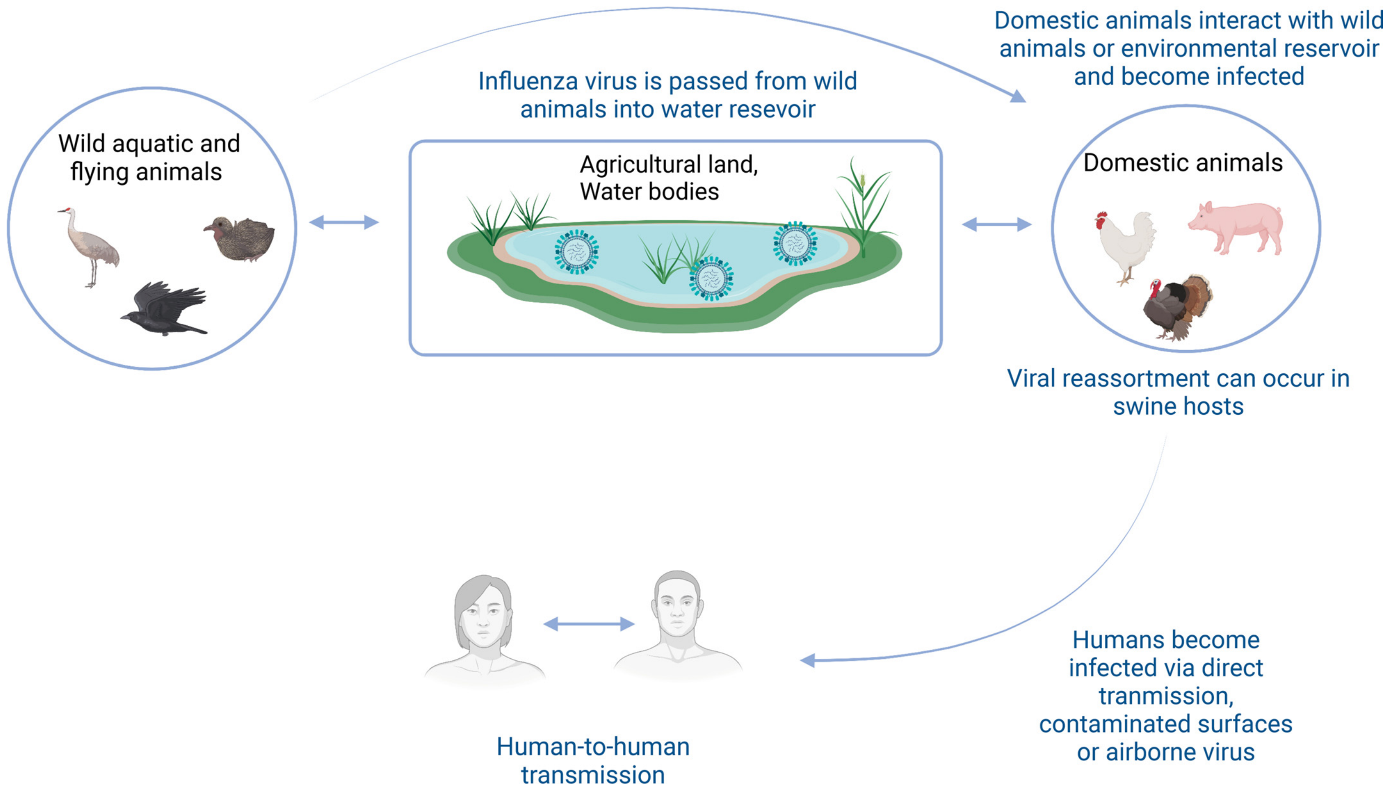


Fig. 1. Influenza transmission cycle from wild aquatic and flying animals to domestic animals to humans. Wild animals carry the virus and transmit directly or via an environmental reservoir to domestic animals, where reassortment can occur. The virus is then passed to humans via direct or indirect transmission. This figure is adapted from Parvin et al., 2020 [21].

planetary changes, it is crucial to understand the mechanisms through which climate change affects influenza and the extent of these impacts. Influenza transmission needs to be considered across a range of players and levels: the virus itself, affected ecosystems, intermediate hosts, and the ultimate human host. Transmission should also be studied across scales, including household, neighborhood, school/workplace, national, and global (Fig. 1). Understanding how climate change affects each level of this transmission cycle is necessary to grasp the full impact of climate change on influenza. Literature reviews have been conducted on various parts of the transmission cycle [7,14–20]. However, to our knowledge, there has not been an overall review of the effects of climate change on the entire transmission cycle of influenza.

To map the research that has been conducted across levels and to identify gaps in the literature, we conducted a scoping review of research relating climate change and influenza. Research on the health effects of climate change is complex and includes a variety of research methods and focus areas. Because a scoping review does not require a narrow research question like a traditional systematic review, this methodology was most suited to our study [22]. The scoping review format allows for a rigorous and replicable method to map the broad research area of climate change and influenza [22].

1.1. Objective

The goal of this scoping review was to map the trends in research on influenza and climate change to gain a better understanding of what research has been done and to identify possible future avenues of research. This scoping review approached this interdisciplinary body of literature through four organizing research areas:

1. The impact of climate change on the seasonality or epidemiology of influenza infections in humans [Human Epidemiology]
2. The impact of climate change on the biology of the influenza virus [Viral Biology]
3. The impact of climate change on influenza infection in animals [Animal Research]
4, The impact of other changes in planetary health on influenza (i.e., non-climatological changes, such as urbanization, biodiversity, or water scarcity) [23] [Planetary Health]

2. Methods

2.1. Search strategy and selection criteria

We examined peer-reviewed literature related to influenza and climate change. Our protocol and reporting were informed by guidance from the Joanna Briggs Institute's report, *JBI Manual for Evidence Synthesis* [22,24–26]. Reporting for this review also relied on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidance [27]. While the PRISMA standards are intended to be used for systematic reviews, they are useful in scoping reviews to increase transparency and reproducibility [25,28].

2.2. Research team

The scoping review project team consisted of two scoping project designers (ML and EB), a librarian who guided the literature search (LT), two members to pull and include/exclude articles (ML and TL), one member to decide on inclusion/exclusion and data extraction conflicts (EB), three data extractors/charters (ML, MW, and JC) and the subject matter expert reviewers (CK, JF, RP, and TG). Team members involved in the inclusion/exclusion process and in data charting were trained on the project purpose, research questions, inclusion/exclusion criteria, and categorization for data charting. The team relied on the systematic review software Covidence (Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia. Available at www.covidence.org) for literature inclusion/exclusion.

2.3. Literature search

We searched a variety of databases including Agricultural & Environmental Science Database, Annual Reviews Online, EMBASE, and PubMed for literature related to influenza and climate change. The search strategy included key words such as 'climatological,' 'meteorological,' 'change,' 'influenza,' and 'outcome.' The full list of search terms and databases is available in the Appendix.

2.4. Study selection

Prior to the literature search, a list of inclusion and exclusion criteria were created (**Table 1**). The inclusion/exclusion process was conducted in three phases. First, all literature pulled from the databases was imported into Covidence. The software removes any duplicate entries before moving the citations into Title and Abstract Screening. Next, two team members screened each article's title and abstract, using the inclusion/exclusion criteria to determine if it might be relevant. Any conflicts were resolved by a third team member. Last, all relevant articles moved into the Full Text Review where reviewers read through the full text of the articles and decided which to exclude based on the established criteria. A third reviewer decided on conflicts. All included articles then moved forward for data extraction.

2.5. Eligibility criteria

This review included any article published in the selected databases that explicitly referenced both influenza, including human and animal influenza, and climate change or climatological factors in relation to influenza. All papers published through August 11, 2020, were included. Abstracts and conference proceedings, as well as articles published in languages other than English, were excluded.

2.6. Data extraction

A survey built by the project leads was used to extract data. Due to the variety of fields of study included in this scoping review, the survey used different schemes for extracting data for each research area. Extracted information included bibliographic information; study design; methods; quantitative/qualitative findings; and limitations, both author- and reviewer-identified. One hundred seventy-four (174) papers were included in data charting. Reviewers were trained over two weeks to a) orient to the evidence base, b) ensure a common understanding of the research questions, and c) ensure correct use of the survey and establish interrater reliability for charting data. Interrater reliability was established prior to extraction through practice reviewing rounds that measured agreement between charters. This process included iterative changes to the data charting survey when more specificity was required. Once agreement was established, data charting began. For each article, two reviewers independently charted data using the survey. Reviewers were free to discuss articles with the group if questions arose as to how to categorize the data. If there was disagreement in the data charting, the article was reviewed by a third reviewer.

In this paper, we map the research that has been conducted in each of the research areas: Human Epidemiology, Viral Biology, Animal Research, and Planetary Health, as well as the common study limitations cited by researchers. We delve further into the first category, conducting an in-depth review of research relating to the impact of climate change on the epidemiology of influenza. The depth of primary research conducted on this topic allowed for a more detailed analysis of this research area. Finally, we provide an overview of possible future areas of research.

3. Results

3.1. Study inclusion

A total of 19,549 texts were retrieved from the database search. After deleting duplicates, 12,839 articles were assessed for relevance, and 341 full texts assessed for eligibility. Of those, 168 were excluded (96 not related to climate change, 49 abstract only/no English full-text, 22 not about influenza), leaving 174 texts for data charting. Fig. 2 shows the PRISMA diagram summarizing this selection process. The PRISMA-ScR Checklist is included in the Appendix. One-hundred thirty (130) articles were primary research, 39 were literature reviews or meta-analyses, and two were editorial or opinion articles (**Table 2**).

3.2. Dates of publication and journals

From the earliest publication in 1977, the number of publications has increased over time (**Fig. 3**). Three publications were published prior to 2000, 25 (14%) were published between 2000 and 2010, and 146 (84%) were published between 2011 and 2020. Nearly half (n = 81, 47%) were published from 2016 to 2020. Included articles were published across 106 journals. The most common journal was *PLoS One* (n = 39), followed by the *International Journal of Environmental Research and Public Health* (n = 8) and *Influenza and Other Respiratory Diseases* (n = 8). The increase in publication seems to align with the increase in highly pathogenic avian influenza (HPAI) outbreaks, especially those in the mid-2000s, and efforts to understand its spread [30]. The increase also seems to echo the growing focus on planetary health from national and international organizations.

3.3. Geographical areas studied

In total, primary research was conducted on data from 54 countries (**Fig. 4**). The most studied countries were China (n = 29 studies,

Table 1
Inclusion and exclusion criteria for selection of articles for review.

Included	Excluded
All publication dates (through August 11, 2020)	No English full-text publication available
All geographical locations	Conference proceedings or abstracts
Full-text published in English	Outcomes only related to influenza medication, vaccination, or public health programming
Published study, governmental report, nongovernmental report	Lacking an explicit reference to the impact of climate change and/or seasonality and/or climatological factors on influenza
Health outcomes reported for human or animal influenza	
Explicit reference to an impact of climate change and/or seasonality and/or climatological factors on influenza	

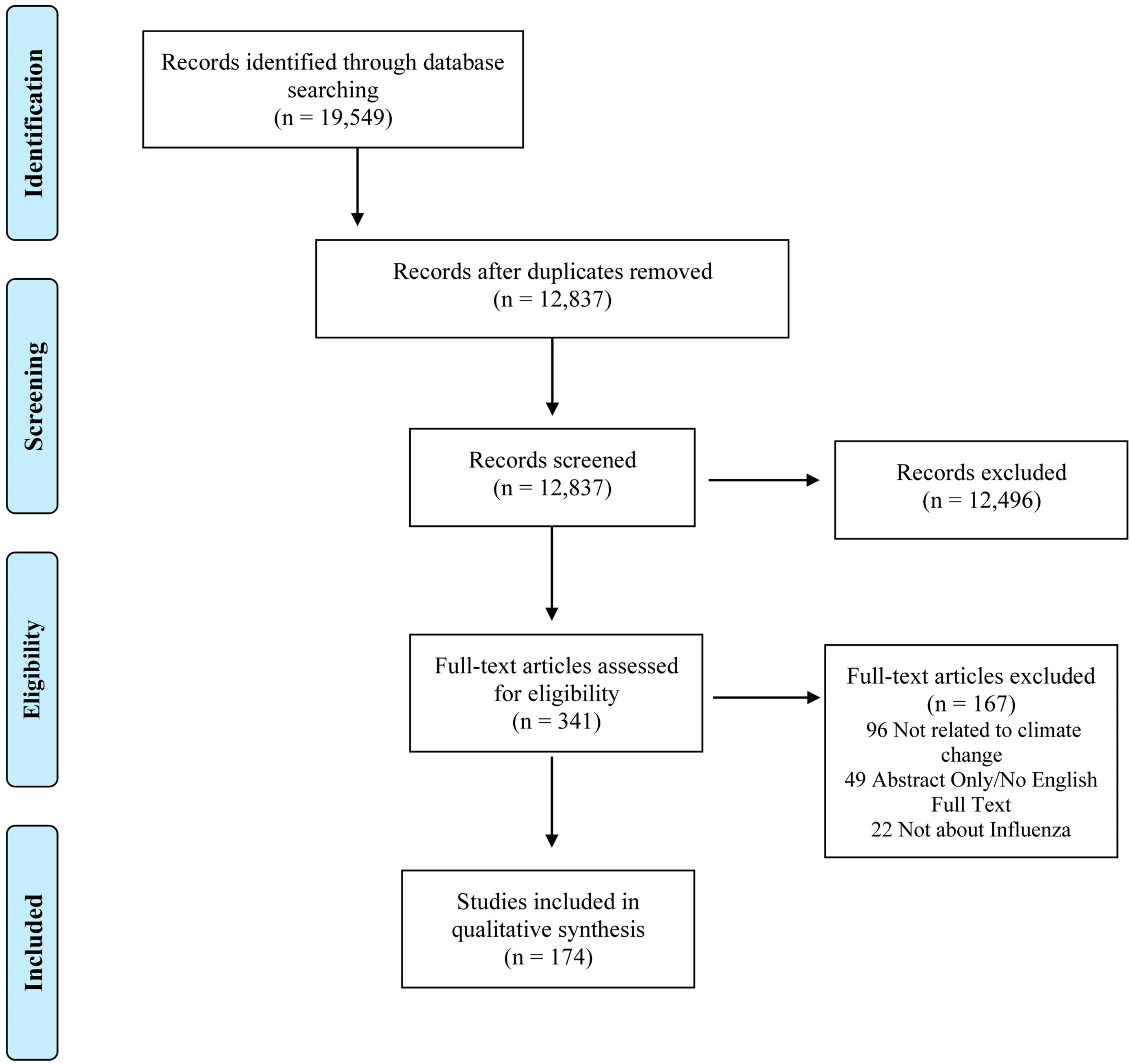


Fig. 2. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart diagram for full-text selection for Climate Change and Influenza: A Scoping Review [29].

17%) and the United States (*n* = 21, 12%), two countries that have experienced HPAI outbreaks in the last few decades. Epidemiological research was conducted around the globe, with Asia being the most represented continent (*n* = 39), followed by Europe (*n* = 19) and North America (*n* = 17). Animal research was conducted mostly in Asia (*n* = 6), Europe (*n* = 6), and North America (*n* = 4). Research examining bird migration paths was conducted across continents.

3.4. Research topic areas

The reviewed articles were synthesized according to the scoping review categories they addressed: Human Epidemiology (*n* = 123), Viral Biology (*n* = 36), Animal Studies (*n* = 36), and Planetary Health (*n* = 41) (**Table 2**). Forty-four (44) studies addressed multiple categories and were included in each addressed category.

3.5. Climatological variables assessed

Across the primary research articles (*n* = 130), the most assessed climatological variable was temperature (*n* = 114, 88%), followed by precipitation (*n* = 59, 45%) and relative humidity (*n* = 59, 45%). Absolute and specific humidity were also commonly studied factors, and some studies did not clarify the type of humidity that was assessed (**Fig. 5**).

3.6. Human epidemiology

Most primary research articles examining the impact of climate change on influenza studied epidemiology (*n* = 103). Because of the large focus, we further examined this research area to better understand the association between influenza epidemiology and climatological factors. Of the 103 primary research articles in this category,

Table 2
Descriptive analysis of included primary research articles on climate change and influenza by research topic area.

Research Area and Topics	Primary Research Articles (% primary research articles) Number of topic area articles (% research area articles)		Secondary Research Articles (% of secondary research articles) Number of topic area articles (% of research area articles)	
Epidemiologic Measures	**103**	**79%**	**20**	**45%**
Incidence	79	77%	12	60%
Mortality	17	17%	6	30%
Hospitalizations	9	9%	2	10%
Geographical Distribution	35	34%	6	10%
Timing of Season (start/end)	36	35%	8	30%
Influenza Season Length	4	4%	0	0%
Other (i.e., peak timing, prevalence, morbidity)	8	8%	2	10%
Biological Factors	**16**	**12%**	**20**	**45%**
Transmissibility	2	13%	6	30%
Viral Mutation	3	19%	3	15%
Viability	11	69%	9	45%
Animal Factors	**20**	**15%**	**16**	**36%**
Animal Migration	14	70%	14	88%
Other Animal Behaviors (e.g., wild-domestic animal interface)	8	40%	8	50%
Epidemiology of Animal Infection	17	85%	13	81%
Other	2	10%	1	6%
Planetary Health Factors	**18**	**14%**	**23**	**52%**
Water Scarcity	0	0%	2	9%
Changing Food Systems	9	50%	15	65%
Urbanization	4	22%	5	22%
Biodiversity Shifts	1	6%	4	17%
Global Pollution	3	17%	3	13%
Natural Disasters	0	0%	0	0%
Changes in Soil and Water Quality	1	6%	0	0%
Changing Land Use (e.g., habitat destruction)	5	28%	13	52%
Population Density	6	33%	1	4%
Globalization	1	6%	5	22%

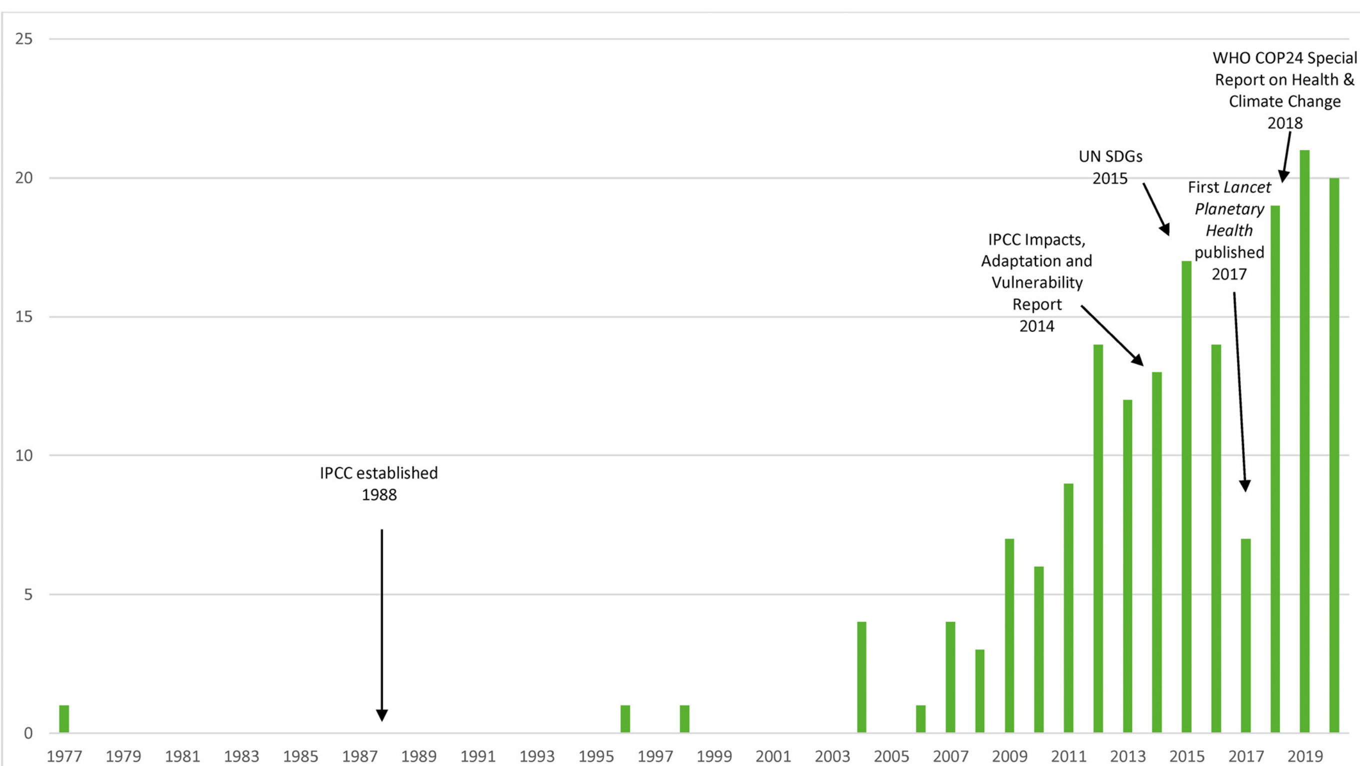


Fig. 3. Articles on climate change and influenza published by year, overlayed with relevant events. 47% of research was conducted between 2016 and 2020.

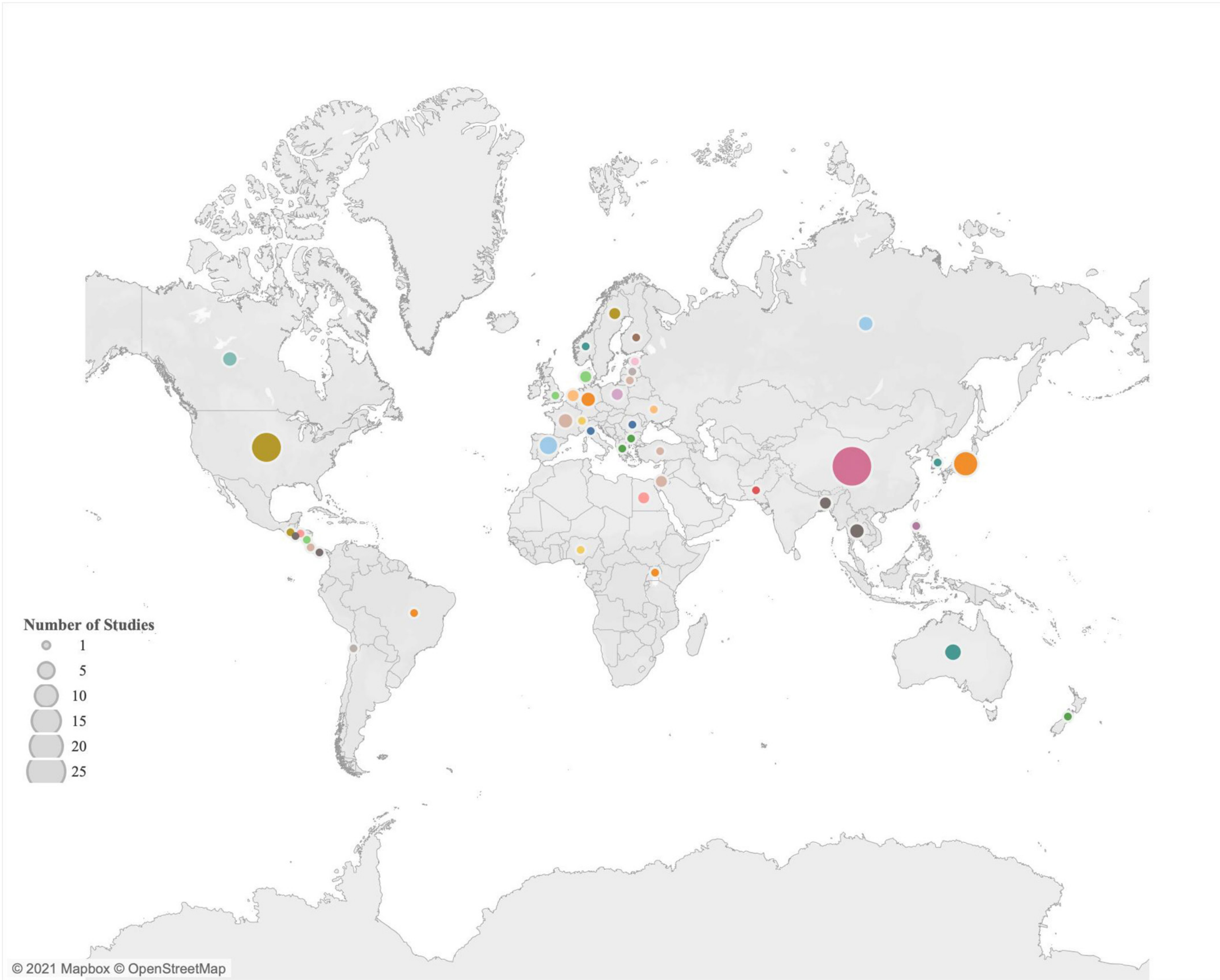


Fig. 4. Locations of included research articles on climate change and influenza. The color of the bubbles indicates the country of research with the size indicating the amount of research done in that country.

93 found a directional association between an epidemiological factor and a climatological factor (**Fig. 6**). The most studied climatological factor in the epidemiology articles was temperature (n = 84), followed by relative humidity (n = 50), precipitation (n = 49), and absolute humidity (n = 29). Other climatological factors studied include sunshine duration (n = 13) and wind speed (n = 12).

3.6.1. Epidemiological factors examined

Some of the included studies examined the impact of climatological factors averaged over a period, while others observed this relationship over a lag period following a climatological event. For papers that found an association between an epidemiological and climatological factor, the most common epidemiological factor examined was incidence. Mortality and hospitalizations were much less frequently studied (**Fig. 6a**). The direction of observed associations differed between studies (**Fig. 6b**). While some studies found a unidirectional association between a climatological and epidemiological factor, some found no relationship (neutral), and others found a bidirectional relationship with a threshold point for the climatological factor.

Most studies that found an association between temperature and incidence of influenza saw an inverse relationship, with lower temperature associated with higher incidence (**Fig. 6b**). Those examining absolute humidity also often found a negative association with incidence. The associations between incidence and precipitation and relative humidity were less consistent across studies. Mortality and hospitalizations were much less often studied, making a summary analysis difficult.

In epidemiological research, there are limitations of data sources which rely on a variety of methods for data collection and reporting, have differing methods for testing for influenza, have low data quality, or are not representative of the general population. Gathering climatological data at the local level, especially in conjunction with the epidemiological data, can be another challenge, making it difficult to ensure that the weather data used in an analysis applies to the entire population being studied in terms of geography and temporality. Other limitations include challenges in determining causal mechanisms for the relationship between climatological and epidemiological factors, the need for inclusion of other confounding factors (i.e., vaccination rates, school schedules, etc.), and the need to include an analysis by viral subtype. Additionally, there are other factors that impact an individual's likelihood of contracting influenza that often have not been examined in climatological analyses, such as health vulnerabilities due to housing, healthcare access, and other social

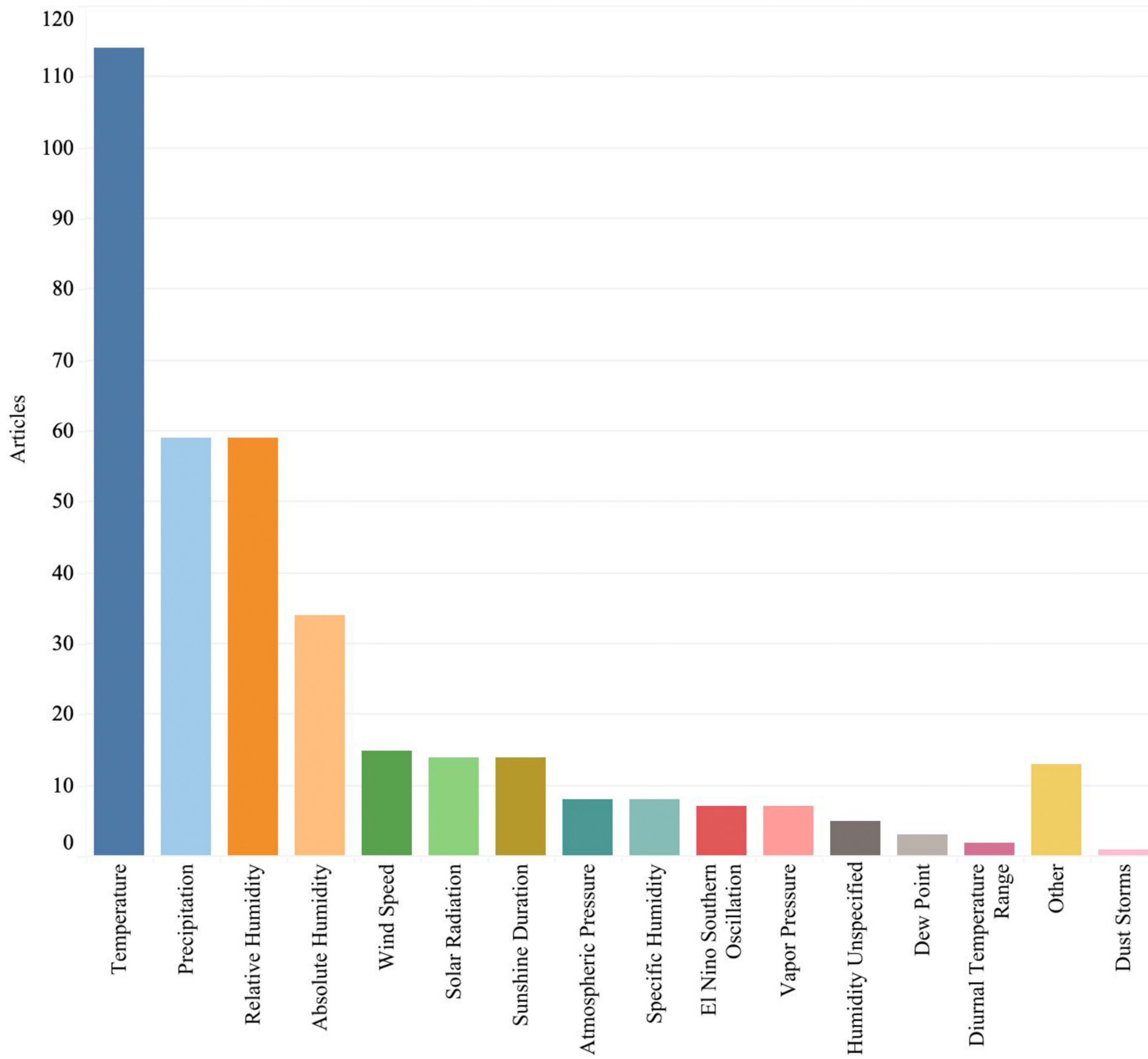


Fig. 5. Climatological variables studied across included articles on climate change and influenza.

determinants of health impacting health equity. The ability to measure the environment indoors may also improve our understanding of the outcomes of climate and disease models given that humans spend most of their time indoors, and factors like air conditioning, heating, household crowing, and indoor air quality play a role in health outcomes.

3.7. Biology

Sixteen primary research studies explicitly examined the association between climatological factors and the biology of the influenza virus. The topics studied include transmissibility (n = 2, 13%), viability (n = 3, 19%), and viral mutation (n = 11, 69%). The most assessed climatological factor in the biology studies was temperature (n = 13, 76%), followed by relative humidity (n = 4, 24%) and precipitation (n = 4, 24%). Temperature, UV radiation, and relative humidity were generally found to be inversely related to influenza virus viability, infectivity, and transmissibility in vivo, though the strength and linearity of this effect differs between virus types [31–34]. Low temperature was also found to be correlated with high mutation rates of the hemagglutinin protein of the virus, which may affect transmissibility through its ability to adapt to new environments, evade host immune systems, and generate drug-resistant strains [35–37].

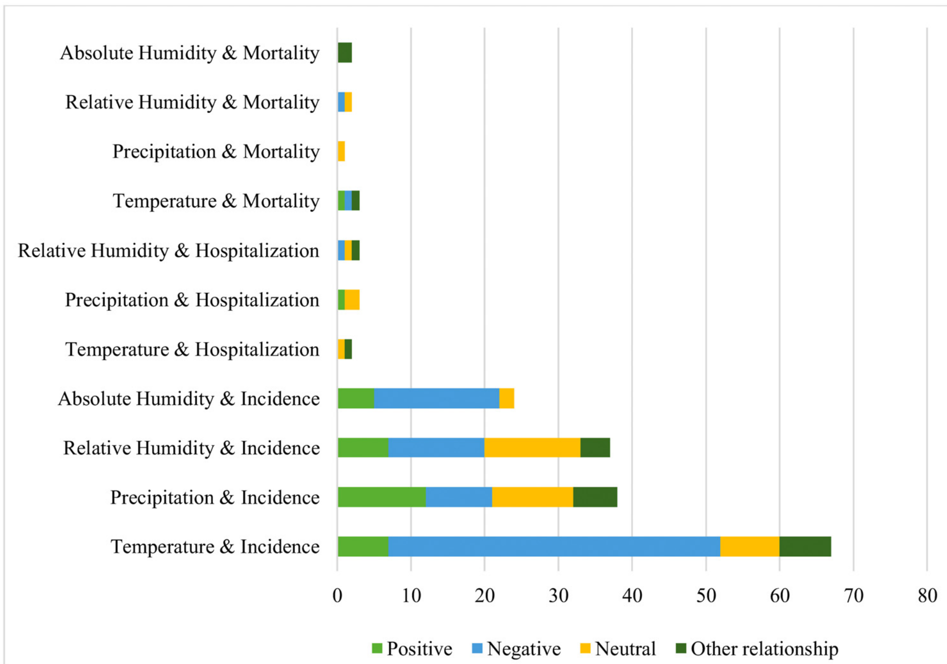
The researchers across these studies suggest examining relationships between climatological factors and influenza infectivity or biology across smaller timescales (e.g., not annual data) and different geographies (e.g., tropical climates). Additionally, there is a need to determine if the relationships between climatological factors and influenza biology are casual, as well as to include additional factors in these models as possible confounders.

3.8. Animal research

Of the 20 primary research articles that addressed animals and influenza, 17 (85%) examined the impact of climatological factors on the occurance of influenza in animals, with most articles focusing on avian influenza. Fourteen studies (70%) discussed the impact of climate change on animal migration and the resulting impact on influenza transmission. The most studied climatological factor was temperature (n = 18, 90%), followed by precipitation (n = 9, 45%) and relative humidity (n = 4, 20%). Other climatological factors assessed include El Niño Southern Oscillation effects, wind speed, solar radiation, dust storms, and atmospheric pressure.

The impact of climatological factors on the timing and locations of stopovers in migration was a large area of focus in animal research studies because these changes have an impact on the interaction

a)	Temperature	Precipitation	Relative Humidity	Absolute Humidity	Other Climatological Factor
Incidence	67	38	37	24	19
Mortality	3	1	2	2	1
Hospitalizations	2	3	3	0	4



b)

Fig. 6. a) Heat map of the epidemiological factors examined across studies on climate change and influenza that found an association between an epidemiological and climatological factor. The map shows the number of articles that studied each epidemiological factor in association with the most studied climatological factors. **b)** Associations between the climatological factors and epidemiological factors studied in articles on climate change and influenza.

between migratory and domestic birds and affect the spread of influenza in animals. When studying the intra-species transmission of avian and swine influenza, many researchers found that increasing temperature and precipitation were correlated with decreasing intensity of transmission [38–44], increasing wind speed was correlated with increasing intensity of transmission [38], and decreasing humidity was correlated with increasing influenza outbreaks [41,42]. There is also evidence that avian migration is affected by climate change, with fluctuating climatological factors altering the timing of migration, stopover, and breeding, as well as the availability of breeding sites, which in some cases may lead to increased transmission of influenza between domestic birds and migratory birds [45,46].

A common limitation highlighted by researchers was a lack of data quality assurance related to how consistently cases of influenza in animals are reported, both in terms of definitions and frequency. While influenza cases and mortality in domestic animals may be surveilled closely, it can be difficult to obtain the same data for wild birds. Many authors also argued that future research should expand beyond the specific ecological factors being assessed to include other environmental factors (i.e., farm characteristics, landscapes in the bird migration path, population density). A narrow geographical scope was another common limitation across studies.

3.9. Planetary health

Eighteen primary research studies discussed other planetary health changes that were not addressed in the other categories (viral biology, human epidemiology, or animal research). The number of articles discussing other planetary health changes has increased over time, with most articles published since 2018 (n = 11, 61%). The most studied factor was "changing food systems" (n = 10, 56%), with many articles discussing the increased transmission of avian influenza with the growing number of backyard poultry farms [39,47–49]. Urbanization (n = 7, 39%) and changing land use (n = 5, 28%) were also commonly studied factors, with increasing population density being a driver for transmission of influenza [35,49–54]. Many researchers highlight the need for incorporation of other planetary health factors in future research.

4. Discussion

As weather becomes more variable and less predictable due to environmental changes, there are serious ramifications for community health [55,56]. Therefore, there is a need to bolster health system capacity to avoid further negative outcomes. Research on the effects of climate change on human health are necessary for developing preparedness plans and policies. This scoping review focused on influenza because of its global impact and the availability of research conducted on the disease. Research in this area has increased over time with most studies published within the last decade. This timeline coincides with an increasing interest in the impact of climate change on health, increased outbreaks of HPAI and attention to the pandemic potential of these viruses, publication of the Sustainable Development Goals, and rising discourse around planetary health.

This scoping review highlights some potential future directions for research. While the studies included in this review were conducted across 54 countries, there is a clear need to expand research into lesser studied regions of the world, such as South America, Oceania, and Africa, especially considering these regions have a disproportionate burden of influenza hospitalization and mortality [57]. Most included articles examined the effect of climatological factors on influenza in humans and some research has been conducted on the effect of climate change on influenza in animals, with the largest focus being on avian influenza. However, a common limitation cited by researchers is the lack of understanding of the specific mechanisms by which climatological factors affect the transmission of influenza. This is partially due to a gap in the literature around the impact of climate on the biology of the influenza virus. Additionally, there is a need for deeper understanding of how the climatological factors interact with individual factors, including those that are behavioral. While biological research has shed light on how certain climatological factors impact the stability and mutation rates of the virus in the environment, more research needs to be conducted on the impact of other planetary health factors on the influenza virus and its transmission cycle. There is a dearth of studies on the ecology of the disease, connecting the zoonotic cycle, spillover to domestic animals, and spread in humans.

Temperature, precipitation, absolute humidity, and relative humidity are the climatological factors that have been studied the most. It may be useful to include other factors, such as sunshine duration, wind speed, and air pollution, in future analyses to ensure a fuller understanding of the role of climate in influenza transmission. Similarly, most of the research examined climatological associations with incidence of influenza in humans, so future research may benefit from examination of other epidemiological factors, such as mortality, hospitalization, disease emergence, and pandemic-influenza considerations. Study of these additional factors would expand the opportunity for translation of this research into clinical settings and would help policymakers to bolster healthcare and public health preparedness through the development of methods for allocating resources, finding ecosystem-based solutions, targeting surveillance and prevention efforts, and preparing for future effects of climate change on influenza. This review did not attempt to examine research on demographic factors, though this is an important area of consideration for clinical translation.

This review found that discussion of planetary health factors, such as anthropogenic factors, was not very common across the included studies. Only 14% of articles mentioned the planetary health factors that were considered in this study, with the majority focusing on changing food systems and population density. It is probable that other factors, such as changing land use, biodiversity changes, and water scarcity play a role in the relationship between climate and the transmission cycle of influenza, given that they impact influenza directly and may exacerbate climate change, thereby indirectly impacting the influenza transmission cycle. Therefore, future research needs to consider both climate change and other planetary health factors in the examination of impacts on influenza transmission.

A strength of this scoping review is the inclusion of studies across a wide variety of fields. Using a systematic search and data charting strategy, we were able to map research that has been conducted on various pieces of the influenza transmission cycle. While we employed a wide search strategy, a limitation of our review is that we were unable to include studies unavailable in English. This can induce selection bias in the inclusion process, although strict inclusion/exclusion criteria were used, and multiple reviewers completed the selection and data charting process. The total number of articles excluded for this reason was 49, the majority of which were published in Chinese languages. There may have been bias induced through our search terms that were developed a priori and were not adjusted throughout the review process. For instance, we may have missed articles discussing health effects on children specifically by not using ‘children’ as a term in our search. Our use of the term ‘admission’ may not have been globally applicable, and the search terms for planetary health factors may not have been inclusive of all related terminology. Due to the large scope of this review, we were also unable to conduct meta-analyses of the data from the included articles. This further analysis is beyond the scope of this type of literature review. However, future work will delve further into the data to conduct a meta-analysis of the epidemiological research included in this review to gain a clearer understanding of the research findings across articles.

Overall, this scoping review highlights the research on the effects of climate change on influenza, as well as the difficulty in understanding these effects at each step in the transmission cycle. This topic area is of ever-growing importance, so researchers must recognize and examine current gaps in knowledge and focus on understanding the mechanisms through which climate change affects influenza and expanding scope to include more geographical areas.

Contributions

ML, CK, JF, TG, RP, and EB generated the study idea and ML, CK, and EB designed the methods. ML, MW, JC, TL reviewed the literature and charted data. EB acted as the third reviewer in cases on disagreement. ML, MW and JC wrote the first draft of the manuscript. CK, EB, RP, JF, TG and UK contributed and reviewed the manuscript.

Declaration of Competing Interest

No authors declare any conflicts of interest during the conduct of the study.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.joclim.2021.100084.

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