Climate Change and Aging: A Systematic Review

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Abstract

In this systematic review, we analyze the literature through Web of Science's SCI-Expanded containing the words "aging" or "aged" and "climate change" and receiving at least four citations per year since publication (n = 607 articles). After discarding irrelevant articles (ie, "aging infrastructure"), the 177 remaining articles overwhelmingly (51%) fall into two categories: temperature/mortality (n= 67; 38%) and temperature/morbidity (n = 24; 14%). However, many other important climate topics related to aging remain underdeveloped. Notably, adaptation (n = 50; 29%), vulnerability (n = 27; 16%), emissions/mitigation (n = 19; 11%), climate perceptions (n = 13; 8%), drought (n = 4; 2%), and food security (n = 2; 1%) remain understudied. Furthermore, more than half of the studies were conducted in the United States (n = 46; 26%), China (n = 0; 0%), Globally (n = 21; 12%), and Australia (n = 11; 6%), suggesting a paucity of information in the Global South (n = 11) where climate impacts will be greatest. There were more studies specifically on Spain (n = 12) than specifically on the entire African continent (n = 5). Finally, 27 articles (16%) offered projections in some form, most to the middle of the century. Gerontologists and aging scientists should look beyond the relationship between heat and mortality to offer a more holistic view of aging and climate change. Prospective analyses, as opposed to retrospective, could shed additional light on the link between aging and climate change.

Keywords: population aging; demography; climate impacts; mitigation; adaptation

1 Introduction

Two seemingly immutable trends will crash head-on during this century: the global populace will continue to age and global climate change impacts will worsen as the century progresses. By the end of the century, when climate change impacts will be considerably more intense than today, the Global populace exposed to these impacts will be decidedly older, amplifying climate change impacts. Many of the anticipated impacts from climate change disproportionately impact older adults versus younger, more vigorous age groups making these two trends particularly potent when taken together.

Consider this: the Global populace will age universally. The global population aged 75+ is expected to grow from 271M people today to nearly 1.4B people by 2100 (Division, 2019). Today, only Japan, Italy, and Germany have median ages in excess of 50. But by 2100, 54% of countries will be as old as or older than these countries are today. These demographic trends are well known (Lutz et al., 2008; Beard et al., 2016).

While the global, dramatic aging shift occurs, the world will continue to warm. Climate projections suggest global temperatures are likely increase more than 3 degrees Celsius by 2100 compared to the pre-industrial period (Arias et al., 2021). These temperature increases will likely usher in increasingly frequent and destructive extreme weather events, more frequent droughts and wildfire risks, extreme heat, and substantially increase the burden on health services (Pörtner et al., 2022). Low-lying coastal areas will experience increased coastal flooding and the submergence of many coastal cities appears likely (Kulp and Strauss, 2019). Climate change will make the world of 2100 considerably more precarious compared to today, a precarity amplified by a globally aging populace.

Nearly every climate impact is heightened by age due to the older people's social vulnerability and physiological susceptibility. Older adults have increased social vulnerability

to psychological stresses due to environmental change, reduced ability to adapt, limited transportation, reduced mobility, smaller social networks, lower incomes, chronic health problems, social isolation, cognitive decline, and general fragility (Kovats and Hajat, 2008). This elevated social vulnerability combines with older adult's increased physiological vulnerability to extreme heat and cold, extreme weather events, and infectious diseases to create a biophysical cocktail of potential catastrophe.

Additionally, climate change and aging intersect in multiple ways, beyond just climate impacts. Older adults play important roles in the mitigation or reduction of carbon emissions (O'Neill et al., 2010; Büchs and Schnepf, 2013). Adaptation to climate impacts greatly vary among older populations (Huang et al., 2011; Guo et al., 2012) and perceptions of climate risks can serve as barriers to effective adaptation (Hansen et al., 2011; Abrahamson et al., 2008). Yet, as we show in this article, most research concerning aging and climate change tends to focus on the impact of extreme temperatures on older populations. A more holistic view of the aging and climate change literature could shed light on the varied relationships between older adults and global environmental change.

In this article, we conduct a systematic review of the literature surrounding climate change and aging to show two primary things. (1) We want to show how the topic of "climate change and population aging" has changed over time; whether there is growing interest in the topic, etc. (2) We want to show the primary topics where most research activity in this area exists in order to find gaps in the research literature.

2 Methods and Materials

We use a systematic literature review to assess the literature on climate change and aging.

2.1 Document selection

We used a keyword search on Clarivate's Web of Science-expanded search engine using the Boolean operator "TS=(aging OR aged OR elderly) AND TS=("climate change")." We selected Web of Science due to its comprehensive scientific coverage of peer-reviewed literature. We conducted the search on September 7, 2022. This search retrieved an initial universe of 16,828 articles. We filtered these results to include articles of relatively high impact, defined subjectively as those articles with at least four citations per year (n = 3,852). To further isolate those articles pertaining to aging and climate change, we further restricted our search to those articles containing the words (aging or aged or elderly) in the abstract (n = 607).

We then reviewed these articles for relevance, discarding articles concerning "aging infrastructure" or "aging forests" to isolate articles on human aging and climate change. This yielded a total of 177 articles included in this systematic review (**Figure 1**).

2.2 Document review

Following our document selection and screening, 607 articles were retained for full review. We developed a questionnaire to survey these articles to document and characterize the primary topics of climate change. We developed this questionnaire to standardize the analysis, produce descriptive statistics, and examine trends. We coded all papers based on:

(1) the primary and (2) secondary climate effect studied,

(2) the climate impact type (sensitivity, vulnerability, or exposure),

(3) the climate impact studied (morbidity, mortality, etc.), if the article concerned

(4) mitigation, (6) adaptation, or (7) perceptions,

(5) if the article included a projection,

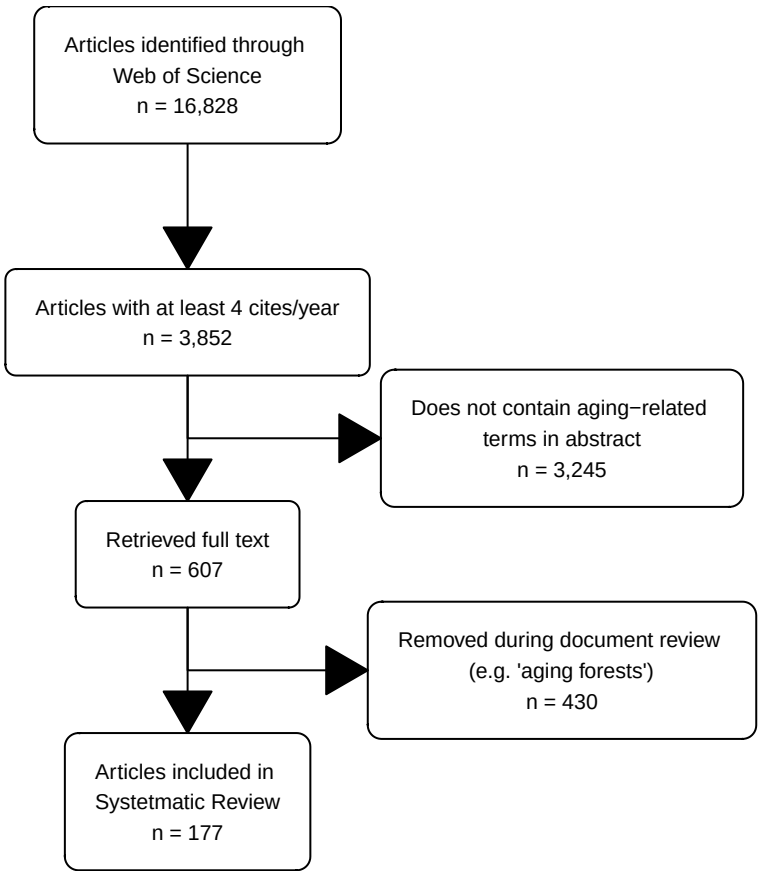

Figure 1: PRISMA Flow Diagram.

(6) the historic time period, and

(7) the general area the study was conducted.

Additionally, we gathered general information on authorship, publication year, and citation counts. We conducted an extensive full-text review of all (n = 607) articles using this questionnaire. We assessed the primary finding in articles where multiple climate impact types or climate impacts were studied.

2.3 Analysis

All (n = 16,828) articles were retained for validation. All data were entered into an Excel spreadsheet. We used R to analyze the data and to produce descriptive statistics and visualizations.

3 Data Availability

The underlying computer code and data that support the findings of this study are available in the Supplementary Material and have been deposited in Zenodo (DOI).

4 Results

4.1 General Interest in Aging and Climate Change

Figure 2 shows the trends in articles (**Figure 2a**), cumulative citations (**Figure 2b**), and average citations per year (**Figure 2c**) for our compendium on 'climate change and aging.' Our compendium shows that the number of articles has been steadily increasing since 2000, peaking in 2019, most likely due to the exclusion criteria of four citations per

year. However, the total number of citations in our database peaks much earlier in 2010. This peak roughly coincides with the publication of the IPCC's AR4 report in 2007 and with several publications documenting heat mortality associated with the 2003 European summer heatwaves. The increasing number of published articles per year is encouraging but it is discouraging that the more recent literature is likely having less impact than the older literature in this area.

4.2 Population Aging and Climate Effects and Impacts

Figure 3 illustrates the co-occurrences of climate effects and climate impacts. The overwhelming majority of articles in our sample concerned temperature as a climate effect (n = 98). Some examples of climate effects which were classified as temperature include heat (n = 29), heatwaves (n = 18), daily temperature range (n = 9) and ambient temperature (n = 8).

The large majority of articles in our sample concerned the climate impact on mortality (n =81) and morbidity (n = 31). The morbidity category included articles which specifically observe "morbidity" (n = 22), hospital admissions (n = 8) and ambulance attendance (n = 1), among others.

More than half of the articles in our sample which included climate effects were specifically about the impact of temperature on mortality (n = 88). The second most frequent climate effect and impact to be studied together was temperature and morbidity (n = 35). The studies in our sample overwhelmingly find that higher temperatures are associated with elevated mortality and morbidity among older populations. Our findings suggest that the most popular climate change features studied in relation to aging populations are temperature effects like heat index and temperature variability on morbidity and mortality

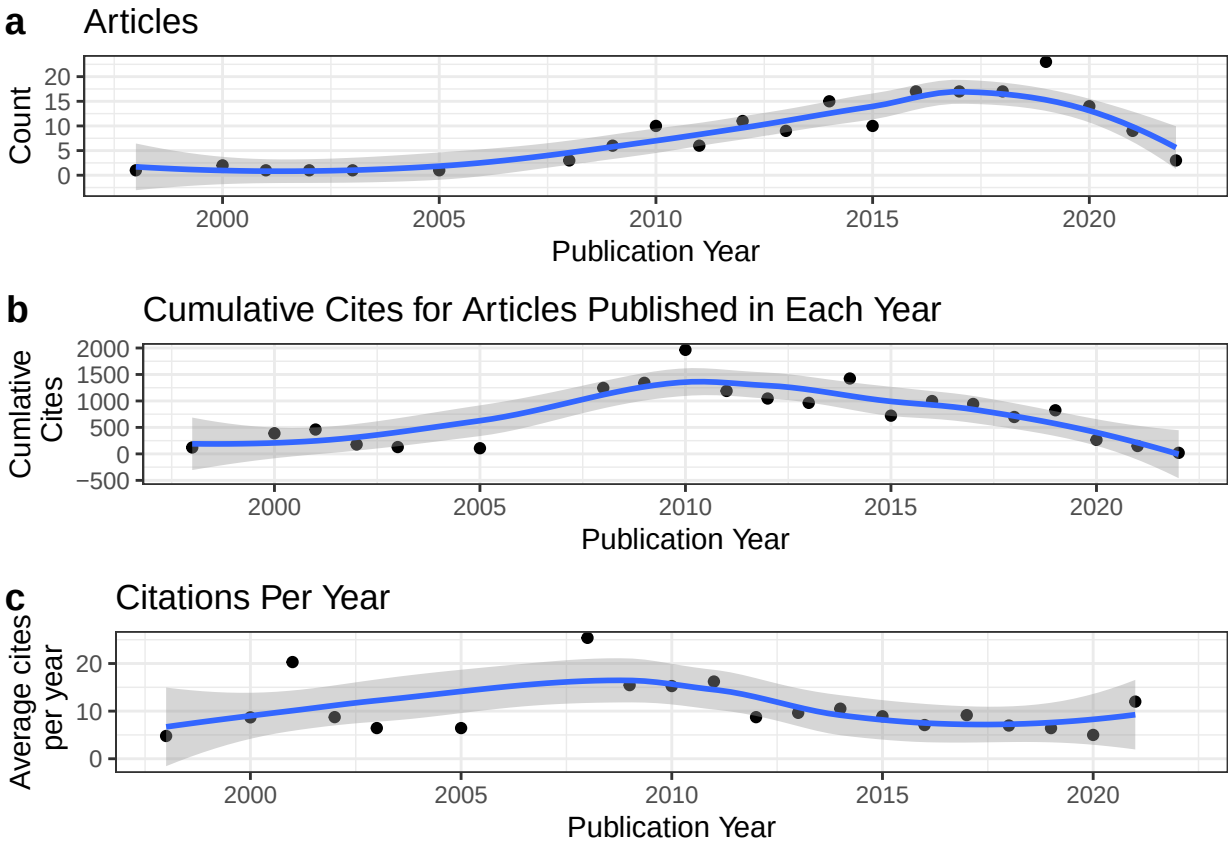

Figure 2: **Published articles, cumulative citations, and citations per year since 1998 for 'aging' and 'climate change' articles reviewed.** (a) shows the number of articles published each year, (b) shows the cumulative citations for articles published in each year, and (c) shows the citations per article per year. Articles published have increased since 1998, but there has been a small decline in this literature since 2020. The most cited articles and the citations per year per article peaked more than 10 years ago, possibly suggesting a waning interest in this literature.

metrics like hospital attendance or years of life lost.

There is also a small section of literature which concerns the effect of pollution on aging populations (n = 17). Two-thirds of these articles, like temperature, concerned pollution's impact on either mortality (n = 6) or morbidity (n = 2).

There is a paucity of information on how droughts, extreme weather, and sea-level rise (SLR) will impact aging human populations. Cumulatively, 12 articles observed any of these effects of climate change. Specifically, we find that pollution, flooding and SLR, extreme weather and wildfires, and drought are understudied in the literature. Climate impacts are incredibly varied in the broader climate change literature but *not* in the climate change and aging literature.

Importantly, very few articles observe the relationships between the broader set of climate effects and human behaviors, such as migration, economic activity, and climate behaviors & policies (n = 3). Only studies examining morbidity and mortality concerned multiple climate impacts. This gap is particularly pressing because it speaks to aging populations' abilities to respond to climate change. It is conceivable that aging populations may respond to sea-level rise with migration, urban heat islands with outdoor green spaces, extreme weather events with improved household infrastructure, or seasonal temperature variation with voting behavior. All of these examples demonstrate how climate effects can impact human behavior and, consequently, adaptive capacity among older populations, yet all remain understudied.

4.3 Older Adults' Vulnerability to Climate Change

Table 1 reports broad categories of the components of vulnerability. Vulnerability is often given as the function $V = E \cdot S \cdot A$, where Vulnerability is equal to the product of Exposure

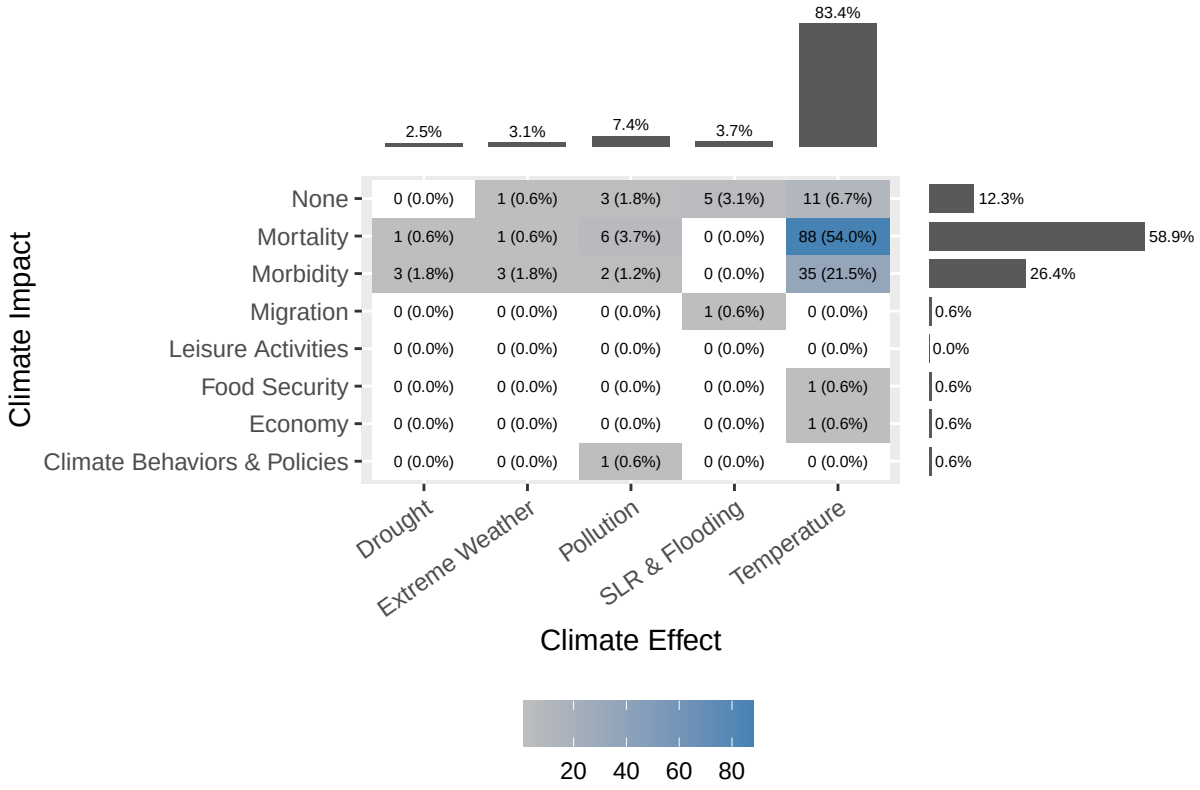

Figure 3: **Heatmap of Common Characteristics.** Here we show the commonalities in the papers we reviewed. The numbers in each square show both the number and relative frequency of the joint climat impact/effect. Most articles on 'Aging and Climate Change' concern the relationship between temperature and mortality (86 articles or 54%) or temperature and morbidity (35 articles or 21.5%). Very few studies touch on other climate impacts such as drought or Extreme weather. Those categorized with no climate impact often investigated exposure or vulnerability, broadly defined.

	Vulnerability	Exposure	Sensitivity	Adaptive Capacity	TOTAL
Vulnerability	25	4	11	0	40
Exposure	4	6	39	2	51
Sensitivity	11	39	38	1	89
Adaptive Capacity	0	2	1	5	8

Table 1: **Number of articles broadly categorized as aspects of Vulnerability.** Vulnerability is often defined as VESA, where Vulnerability is equal to exposure multiplied by sensitivity multiplied by adaptive capacity. Most published research on climate change and population aging focuses on sensitivity and exposure while very little published researches concerns adaptive capacity. A large number of articles (n=40) use an amphorous definition of 'vulnerability.'

to a climate hazard, Sensitivity to a given climate hazard, and Adaptive capacity (Field and Barros, 2014; Parmesan et al., 2022). However, the scientific literature surrounding population aging and climate change overwhelmingly studies vulnerability as a function of exposure (n=51) and sensitivity (n=89), with very few studies on vulnerability concerning adaptive capacity (n=8). Furthermore, only ten articles in our sample analyzed vulnerability with the complete complement of VESA. Adaptation potential and gaps among older populations are seriously understudied in the broader literature.

4.4 Aging and Climate Change among Broader Climate Change Categories

Table 2 shows the number of journal articles categorized into broad climate categories to show additional gaps in the climate change and population aging literature. The IPCC is split into three working groups, two of which are highly relevant to population aging:

Impacts/Adaptation/Vulnerability and Mitigation. Less than one-third of articles (n=51) had any form of adaptation to climate change, slightly more than 10% of articles concerned mitigating carbon emissions, and just 7% of articles contained any form of research on perceptions of climate change. Most articles concern some form of climate impact (**Figure 3**) but considerably fewer articles concern adaptation to climate change for older adults. Most articles contained some form of retrospective analysis (n=118) but few studies carried that retrospective analysis into a prospective analysis (n=27) or demonstrating a gap in how future climate change could impact future older adults.

Additionally, mitigating carbon emissions are a key mission of the IPCC to ensure our planet remains habitable in the long term. Unfortunately, few articles (n=13) concern any form of mitigation of carbon emissions among older adults, suggesting a very sizable research gap.

4.5 The Geography of the Literature

We also gathered information on the countries on which studies were conducted. **Figure 4** shows the geographic location of where studies were conducted. Geographically, the literature on aging and climate change could use a lot of work, to put it charitably. China (n= 36), the USA (n=32), and Global (n=21) account for half of the literature. African countries, the average African country has just two studies, South America, dominated by studies on Brazil (n=6), and Southeast Asia, where Vietnam has just a single study, are regions of the world that are still massively understudied in this literature.

The regions most impacted by climate change, but also with the most youthful populations, are the most understudied. And the regions least impacted by climate change, but with the most older populations, are the most studied. There were more studies specifically

	Yes	No	%
Adaptation	51	126	29%
Mitigation	19	158	11%
Perceptions	13	164	7%
Retrospective	118	59	67%
Prospective	27	149	15%

Table 2: **Number of articles broadly categorized as aspects of climate change research.** The IPCC is split into three working groups: the physical science, Impacts/Adaptation/Vulnerability, and Mitigation. The scientific literature concerning population aging and climate change has many articles on Impacts, few on adaptation, and a paucity on mitigation. Additionally, perceptions of climate change is also considerably understudied. Finally, we categorized articles that contained retrospective and prospective analyses. Most articles contained a historical analysis but few concerned some form of projected impact (n=27).

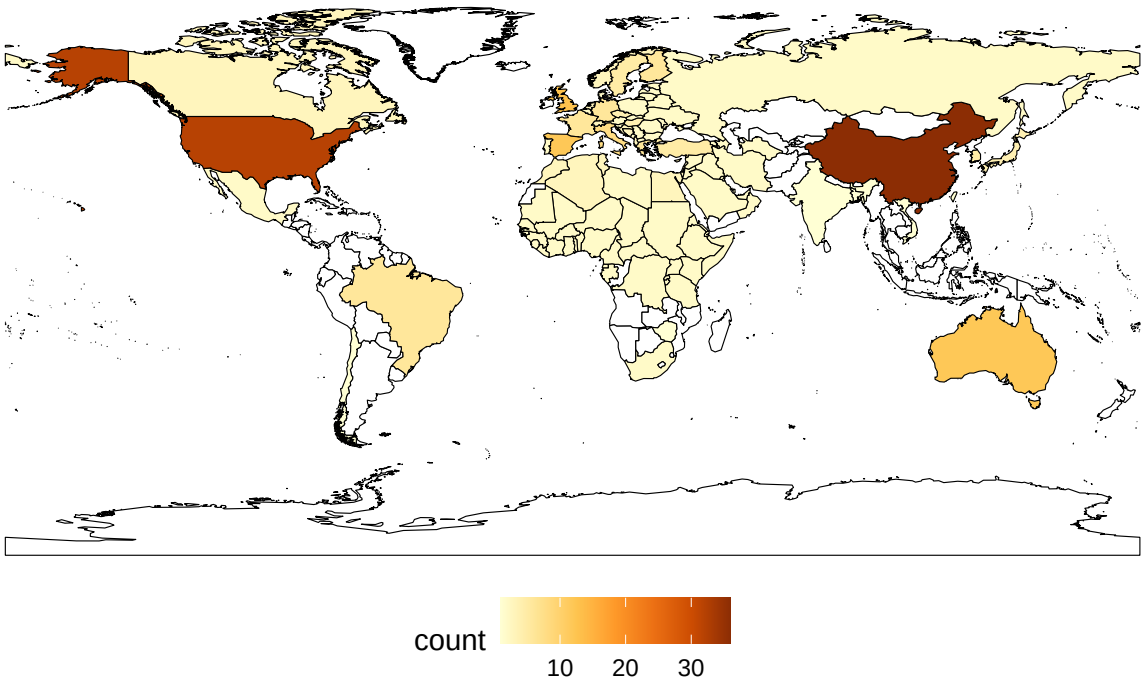

Figure 4: **Map of where studies were carried out.** Here we show the geographic locations of where studies were conducted. Most studies on aging and climate change were conducted in the global north, where most of the current older populations reside rather in the global south, where most of the climate impacts will occur.

on Spain (n = 12) than specifically on the entire African continent (n = 5).

5 Conclusion

In this article, we conducted a systematic literature review of "population aging" and "climate change" to identify the primary topics of research activity. We found that the majority of articles concerned temperature and mortality or temperature and morbidity, finding that older adults are particularly susceptible to extreme temperatures. Climate change impacts go far beyond just temperature yet the literature surrounding these impacts for older adults remain severely underdeveloped. We also show that most studies are conducted in the global north, where presently most of the world's older population resides. Conversely, few studies are conducted in the global south, the locations with the most severe climate impacts.

Based on our analysis we have several recommendations for scientists working at the intersection of population aging and climate change. First, we suggest that scientists broaden their analyses of climate impacts beyond temperature. The IPCC Assessment Report 6 lists a number of climate impacts beyond temperature that include food security, water security, malnutrition, food safety, vector-borne diseases, heavy precipitation events and flooding, migration and displacement, loss of income and livelihoods, international armed conflict, sea-level rise, and economic damages, to name just a few. How these climate impacts will effect older populations is still poorly understood. Scientists would do well to focus on a broader set of climate impacts to better holistically understand how climate change will impact older populations.

Second, we suggest that scientists working at the intersection of climate change and aging broaden their scope of vulnerability. In particular, the literature surrounding older

populations' adaptive capacity is severely limited compared to exposure and sensitivity. The extent to which older adults have the capacity to adapt to climate change and their ability to adapt are still understudied. We know that climate change will change the extent of exposure to climate harms and we largely know that older adults are particularly susceptible to climate impacts. However, the capabilities of older adults to adapt to climate change is still too unknown.

Third, we suggest that scientists focus additional research in the regions that will experience the greatest impacts from climate change. Our understanding of climate change and older adults is still too focused on the developed, global north, where climate impacts are the least intense. We know comparatively very little about how older populations in less developed, global south countries will be impacted by climate change. This is a particularly pernicious gap in the literature since these areas will be impacted the most.

Fourth, mitigation of carbon emissions is a key component to ensure we avoid the most damages from climate change. Yet studies on mitigation among older adults are still a small fraction of this literature. As the global population continues to age, mitigation strategies among older adults will become increasingly important and should receive additional focus from scientists. If we are to develop effective mitigation strategies, older adults will become an increasingly important population.

Fifth, and finally, climate change and older adults goes far beyond climate impacts, adaptive capacity, geography, and mitigation. We reviewed not a single article on older adults and climate denial, for instance. By largely limiting our understanding of climate change to the mortality and morbidity of older adults during extreme temperatures, scientists are missing important topics in climate change such as transitions to net-zero carbon emissions, climate denial, resilience, planned relocation, and inequality. Successfully

tackling the climate crisis will require broader conceptualizations of "climate change" and "aging" than presently found in the scientific literature.

6 Appendix - Articles Included in Review

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