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Review

Urban and Rural Environments and Their Implications for Older Adults' Adaptation to Heat Waves: A Systematic Review

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Abstract: The aim of this study is to synthesise the scientific evidence on the implications of urban and rural environments on older adults' adaptation strategies to heatwaves. Methods: The methodology follows PRISMA guidelines, which involves a systematic search of the scientific literature in selected electronic databases, including Web of Science and Scopus, to assist in the selection, identification and retention of studies. Results: The search identified 4991 potentially eligible articles, of which 17 met the criteria, mainly from developed countries, emphasising a multidisciplinary approach and moderate to low quality. Urban and rural environments influence older adults' adaptation strategies to heatwaves through the adequacy of the physical environment of the dwelling (design, materials, equipment) and the neighbourhood (green spaces, residential density, land use), the social environment (support network and type of assistance) and risk management (protective measures and heat warning systems). At the individual level, adaptation to heatwaves is determined by age, gender, health status, socio-economic status and social isolation. Discussion and conclusions: Differences in perceptions of heat adaptation were found according to location, typology and environmental characteristics, especially in developing countries. The findings contribute to promoting the adoption of protective measures, the design of heat warning systems, and the planning of friendly and resilient cities and rural communities to support the adaptation of an ageing society to the climate warming.

Keywords: urban and rural environments; older people; heatwaves; physical and social environment; vulnerability; adaptation; climate change; systematic review

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1. Introduction

Climate change has significantly heightened the exposure and vulnerability of local communities to natural hazards. Consequently, there is an urgent need to enhance our understanding of how the planning and management of urban and rural environments can inform climate adaptation strategies for an ageing society [1,2].

The climate crisis is characterised by an increase in extreme weather events such as extreme temperatures, droughts, fires and floods [3]. Heat waves, defined as unusually high-temperature events lasting at least three days in a single region, can cause heat stress, disrupt daily life, and lead to adverse health effects in affected populations. Moreover, these extreme events are characterised by a discrepancy between the highest recorded daily temperature and a threshold temperature, which varies by measurement method and region [4–6]. Projections indicate that the impacts of heatwaves will be particularly severe for vulnerable populations in developing regions such as Asia and Latin America [7].

As heatwaves become more frequent, intense, and deadly in the coming years, they will have significant social, economic, and health consequences [8]. These extreme weather events will significantly impact increasing morbidity and mortality, exacerbated by air pollution [9,10]. Indeed, rapid urban growth, land-use change and poor planning aggravate

the issues deriving from high population density, inequality, isolation and severe environmental and climate problems [11]. Moreover, the interplay of adverse climate conditions, land-use changes, overexploitation of natural resources, demographic ageing, and poverty complicates the adaptation to extreme heat in both urban and rural areas [12–14].

In the period between 2000 and 2023, globally, among adverse weather events, extreme heat accounted for 31.6% of all deaths, followed by storms and hurricanes (29.3%), floods (17.2%), vector-borne epidemics (15.8%), and other weather events (6.1%) [15]. In this respect, in the summer of 2003, heatwaves in Europe led to over 70,000 deaths [16]. Increased morbidity and mortality from heatwaves are closely associated with vulnerable groups (the elderly, children, women), adverse socio-economic conditions (inequality and poverty), and pre-existing medical conditions (cardiopulmonary disease, kidney disease, diabetes, mental illness) [17–19].

Some experts suggest that the convergence of urbanisation and demographic ageing is making populations increasingly vulnerable to extreme heat [20]. By 2050, more than 2.1 billion people will be aged 60 years or older, representing one-fifth of the world's population, with a significant concentration in cities, especially in developing countries [21]. Despite this, limited attention has been paid to the dynamic interactions and synergies between demographic ageing and urban challenges such as land-use change, the impact of the built environment, the management of urban ecosystems and environmental degradation [22].

Research highlights that older adults are particularly vulnerable to temperature extremes due to a combination of risk factors such as the prevalence of chronic age-related diseases, multiple pathophysiological conditions and decreased thermoregulatory capacity [23–26]. For instance, in the summer of 2022, Europe reported 61,672 heatwave deaths, of which more than 85% were among people aged 75 years or older [16].

There is strong evidence underscoring the urgent need to better understand the most effective climate measures to prevent and adapt to heatwave risks, especially in ageing and marginalised urban and rural communities [27–30]. Several studies have emphasised the importance of optimising living conditions, as these can play a crucial role in facilitating aging in place and in the development of strategies for physical, social, and environmental interaction to cope with heatwaves [31–34]. Moreover, the characteristics of the physical environment (housing, neighbourhood) can influence the social context, such as the availability of support networks during extreme heat events [35–38].

The literature has questioned the effectiveness of heat warning systems (HWS) and the implementation of protective measures to save lives and reduce damage as exposure to extreme heat increases in urban and rural communities [39–41]. In urban areas, vulnerability to high temperatures is linked to environmental problems such as air pollution, heat islands and lack of green space [42–44]. In rural areas, factors such as limited access to services (health, social), poverty, demographic ageing, and a higher prevalence of chronic diseases increase the risk associated with extreme hot temperatures [45–47]. Nevertheless, the importance of generating knowledge on climate adaptation strategies for older people based on the perception, suitability and planning of urban and rural environments, both physical and social, has been emphasised [48]. Combining scientific data (measurements of climatic variables or of the physical built environment) with the perceptions of older adults can provide a deeper understanding of how climate change will affect their environment and livelihoods. Through this knowledge, it is possible to uncover potential adaptation strategies [49,50].

The aim of this study is to synthesise the scientific evidence on the implications of urban and rural settings for older adults' adaptation strategies with heatwaves. Thus, this article addresses three questions: (1) Which setting (urban or rural) best supports older adults' adaptation to heatwaves? (2) Which physical and social factors in urban and rural settings determine older adults' adaptation to heatwaves? (3) To what extent do older adults' perceptions of adaptation to heatwaves differ between urban and rural settings?

2. Materials and Methods

The first stage of this study was to conduct a systematic review, which involved searching, locating, evaluating, extracting and analysing useful information. The second phase of this work, which addressed the research questions of this review, highlighted the complex interactions between urban and rural environments, ageing and heatwaves. This was achieved through a detailed examination of the selected papers and their specific characteristics.

The aim was to collect relevant information according to specific criteria through a systematic and reproducible search to identify all studies that met the eligibility criteria, to assess the validity of the studies and to summarise the results [51]. This approach did not include a meta-analysis because of the assumed heterogeneity of the potential studies of interest.

This systematic review was conducted according to the key principles of the preferred reporting elements for systematic reviews and meta-analyses (PRISMA). In addition, the PRISMA statement was adopted because it is a recognised approach for systematic reviews in other disciplines and research areas [52,53].

2.1. Search Strategy: Data Source and Search Criteria

Web of Science (WoS) and Scopus were chosen as bibliographic platforms as they are two of the largest and leading databases in the world [54].

To identify the relevant literature, priority was given to research based on primary sources to facilitate an approach to evidence. To this end, the search was conducted using the title, abstract and keyword fields, including the terms and all possible synonyms, plural forms and different spellings of 'heatwave', 'urban', 'rural', 'physical-social environment', 'older people', 'adaptation' and 'vulnerability'. The search syntax for both platforms is shown in Table 1.

Table 1. String of terms used in the search according to the databases.

Search in Web of Science: ((((((((((((((((TS = (heat wave)) OR TS = (extreme heat)) AND TS = (physical environment)) AND TS = (urban)) AND TS = (city)) AND TS = (rural area)) AND TS = (rural)) AND TS = (social environment)) AND TS = (ageing)) AND TS = (elderly)) OR TS = ('elderly')) OR TS = (elderly)) AND TS = ('climate adaptation'))) OR TS = ('climate vulnerability')))))))) and Article (Document Types) and 2024 or 2023 or 2022 or 2021 or 2020 or 2020 or 2019 or 2018 or 2017 or 2016 or 2015 or 2014 or 2013 or 2012 or 2011 or 2010 or 2009 or 2008 or 2007 or 2006 or 2005 or 2004 or 2003 (Years of publication) and English or Spanish or French or Portuguese (Languages)
Search in Scopus: ((ALL (heat AND wave) OR ALL (extreme AND heat) AND ALL (physical AND environment) AND (ALL (urban) OR ALL (city) AND (ALL (rural) OR ALL (rural AND area) AND ALL (social AND environment) AND ALL (ageing) AND ALL (elderly AND people) OR ALL (elderly AND people) AND ALL (heat AND adaptation) OR ALL (heat AND vulnerability) AND DOCTYPE (ar) AND PUBIO > 2002 AND (LIMIT-TO (IDIOMA), (LIMIT-TO (LANGUAGE, 'English') OR LIMIT-TO (LANGUAGE, 'French') OR LIMIT-TO (LANGUAGE, 'Spanish') OR LIMIT-TO (LANGUAGE, 'Portuguese'))

The remaining search criteria were date, document type and language. The publication date was set between 1 January 2003 and 1 April 2024. The start date corresponded to the heatwave that affected Europe in 2003, which had a significant effect on mortality, especially in people aged 65 years and older [55]. The search was limited to journal articles, reviews and monographs, as these are the types of publications that represent the highest quality and have been peer-reviewed. The search was conducted in English, French, Spanish and Portuguese.

2.2. Study Selection and Quality Assessment

The search yielded a total of 4991 articles (4405 from WoS and 586 from Scopus). They were reviewed for suitability and quality with respect to the objectives of the study using the critical appraisal method. The documents were first classified as follows: related to the topic, unrelated and uncertain. Those classified as unrelated and uncertain were eliminated

in the later stages of the analysis. The flowchart of the search and selection of publications is shown in Figure 1.

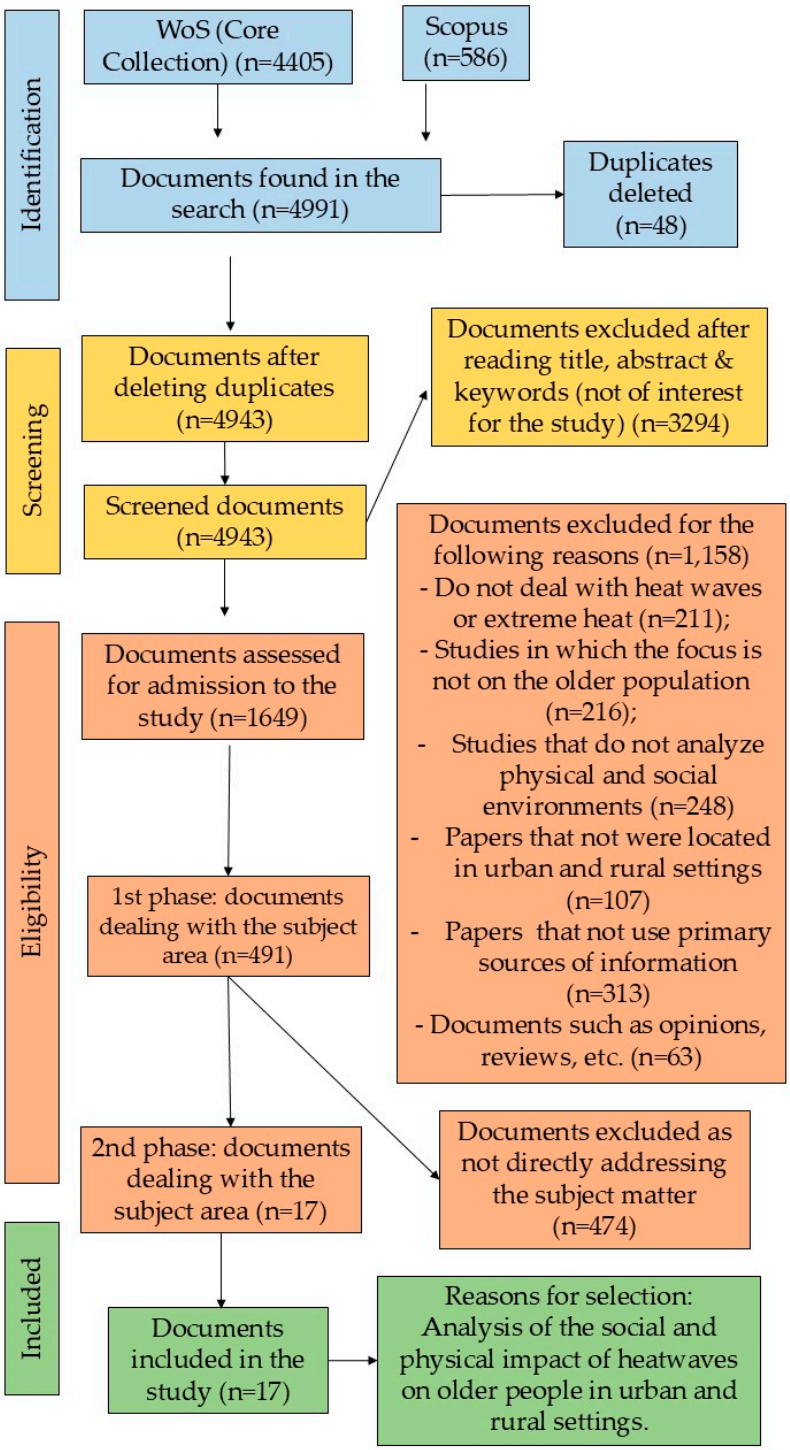

Figure 1. Diagram of the search for information through the different phases of the systematic review.

The elimination of duplicates was carried out using Rayyan Manager and direct observation of the documents, resulting in the exclusion of 48 papers, leaving a total of 4943 records. In terms of the thematic inclusion and exclusion criteria, a total of 3294 documents were eliminated after reading the content of the title, abstract and keywords.

A total of 1158 articles were excluded from this review. The reasons for exclusion were as follows: articles that did not address heatwaves or extreme heat (211), articles that did

not take place in urban and rural settings (314), articles that did not analyse physical and social environments (248), articles that did not focus on the elderly population (216), articles that did not use primary sources of information (313), and articles that were reviews or editorials, commentaries, letters to the editor, and that used languages other than English, French, Spanish and Portuguese (63). Therefore, after the initial screening, selection and eligibility phase, only original studies based on primary sources (or a combination of primary and secondary sources) and using quantitative, qualitative or mixed methods were retained.

2.3. Eligibility Criteria

The second stage of the selection and quality control process involved reviewing the references selected in the first stage to compile studies on the topic. This process considered the importance of the suitability of urban and rural environments in older people's adaptation to heatwaves [56]. Particular attention was paid to the variability in older people's perceptions of urban and rural environments, allowing for a closer look at their experiences and an understanding of how climate adaptation strategies are constructed and shaped.

The first step was to identify and analyse a set of variables related to socio-demographic, health, physical environment, social environment and risk management dimensions. Thus, socio-demographic variables include age, gender, level of education or socio-economic status and living conditions. The health dimension was also represented by variables relating to perceived health status and functional and cognitive problems. Similarly, the physical environment dimension included dwelling variables, including typology, design, materials, equipment, access to services and adaptations made and proposed. At the same time, neighbourhood-related variables were considered, such as location, residential density, land use, access to equipment and services, and climatic shelters [30]. The social environment dimension was also addressed through the variables of social participation, formal and informal support networks, type of help and intergenerational solidarity. In addition, the risk management dimension involved variables related to knowledge and effectiveness of heat warning systems and adoption of protective measures [41].

This review included articles that addressed the topic in urban and rural settings, as well as those that provided a comparative perspective. However, articles that did not present data differentiated between urban and rural areas were excluded [57–59].

A total of 17 references were retained, all of which met the criteria.

2.4. Data Collection and Risk of Bias

Data were extracted independently by the team, who then reviewed and discussed any inconsistencies until consensus was reached. The data tables provide details for each study on participants, methodology, setting (urban and rural) and socio-demographic, health, physical environment, social environment and risk management dimensions and variables (Tables 2–7). In addition, the PRISMA statement and the Cochrane Handbook were used as tools to assess the quality and the type and degree of risk of bias (selection, conduct, detection, attrition and reporting) in the eligible studies. The classification of bias is based on evidence of impact (whether the lack of information had a significant effect on the study results and conclusions), possible alternative methods used (whether the study used alternative methods to mitigate the lack of information), the overall quality of the study, and comparison with similar studies (Table 8) [52,53].

Table 2. Data from studies selected for systematic review.

Authors and Year	Objective	Temporal Focus	Study Area/Scale	Country	Responsible	Inclusion Criteria	Sample Size	Future Lines
Mukhopadhyay & Weitz, 2022 [60]	To analyse the differences in adaptation to extreme heat in older people according to gender, behavioural characteristics and place of residence.	Cross-sectional design	Urban: Kolkata (14.85 million); mega-city Rural: villages 75 km from Kolkata; agrarian settlements (towns and villages)	India	Indian Statistical Institute. Indian Anthropo-logical Society. Temple University.	Age: 60 and over. Health: n/i	130 people from slums and 180 people from rural areas	To promote research from a gender perspective, especially on older women in rural areas.
Weitz et al., 2022 [61]	To understand the heat stress suffered by older people according to urban and rural areas in the summer period.	Cross-sectional design	Urban: Kolkata (14.85 million); mega-city Rural: villages 75 km from Kolkata; agrarian settlements (towns and villages)	India	Temple University	Age: 60 years and older Health: n/i	310 people	To study in depth the connection between heat stress, heat-related illnesses and mortality.
Larrieu et al., 2008 [62]	To quantify the impact of the 2003 heatwave among elderly people from two population-based cohorts.	Cross-sectional design	Urban: Bordeaux (249.712), Dijon (155.114) and Montpellier (277.639); small cities	France	National Institute of Health and Medical Research (Inserm)	Age: 67 and over Health: n/i	2295 people	To develop future intervention plans based on the information obtained
Abrahamson et al., 2009 [63]	To determine elderly people's knowledge and perceptions of heat-related risks to health, and of protective behaviours.	Cross-sectional design	Urban: London (8.982 million) and Norwich (141.300); large cities/small cities	United King-dom	University College London	Age: 72 and over Health: n/i	73 people	To give greater emphasis to a population-based information strategy
Wolf et al., 2010 [64]	To investigate how independently living elderly people perceive their own vulnerability to the effects of heatwaves, and how this might influence their adaptive behaviour.	Cross-sectional design	Urban: London (8.982 million) and Norwich (141.300); large cities/small cities	United King-dom	University of East Anglia	Age: 72 and over Health: n/i	105 people	Further research on the subject

Table 2. *Cont.*

Authors and Year	Objective	Temporal Focus	Study Area/Scale	Country	Responsible	Inclusion Criteria	Sample Size	Future Lines
White-Newsome et al., 2011 [65]	To understand the environmental and structural factors that increase heat vulnerability, as well examine the behaviours used by the elderly to adapt to high indoor temperatures.	Cross-sectional design	Urban: Detroit (620,376); medium-sized cities	United States	University of Michigan School of Public Health	Age: 65 and over Health: n/i	30 people	Further research on the subject
Banwell et al., 2012 [66]	To understand ways in which a vulnerable sub-population adapt their personal behaviour to cope with heat within the context of Australians' relationship with heat.	Cross-sectional design	Urban: Sidney (5.312 million); large cities	Australia	The Australian National University	Age: 65 and over Health: n/i	20 people	Further research on the subject
Bittner & Stößel, 2012 [67]	To explore individual risk perception and adaptive measures of older people and their carers.	Cross-sectional design	Urban: Fribourg (231,195); small cities	Germany	University of Freiburg	Age: 64 and over Health: n/i	20 people	Develop future intervention plans based on the information obtained
Hansen et al., 2014 [68]	To investigate the heat-adaptive behaviours of older people in these states.	Cross-sectional design	Urban: South Australia and Victoria (6.681 million); large cities and its metropolitan area	Australia	University of Adelaide	Age: 65 and over Health: n/i	1000 people	Create plans that incentivize mitigation and adaptation
Wanka et al., 2014 [69]	To improve the chances of successful ageing in urban areas by reducing the vulnerability of older adults above the age of 65 years and living in cities (Vienna) in terms of urban heat.	Cross-sectional design	Urban: Vienna (1.897 million); large cities	Austria	University of Vienna,	Age: 65 and over Health: n/i	601 people	Continue further research

Table 2. *Cont.*

Authors and Year	Objective	Temporal Focus	Study Area/Scale	Country	Responsible	Inclusion Criteria	Sample Size	Future Lines
Lindemann et al., 2018 [70]	To describe the degree of adaptation of social participation and other heat-related behaviour with respect to higher indoor temperatures	Cross-sectional design	Urban: Southern German city; without information on the place of study and scale	Germany	Robert-Bosch-Hospital	Age: 60 and over Health: n/i	81 people	Further research on the subject
Nunes, 2018 [71]	To understand the roles that tangible assets and intangible assets play in the way older adults adapt to extreme temperatures.	Cross-sectional design	Urban: Lisbon (504,718); medium-sized cities	Portugal	University of Warwick	Age: 65 and over Health: n/i	98 people	To implement measures and actions to reduce poverty, reduce energy costs, improve the quality of the housing stock and improve older adults' social networks.
Eady et al., 2020 [72]	To understand seniors' current perceptions of the risks of extreme heat and identify factors that contribute to risk and risk perception.	Cross-sectional design	Urban: Waterloo (113,520); small cities	Canada	University Avenue West	Age: 51 and over Health: n/i	259 people	Further research on the subject
Kemen et al., 2021 [73]	To identify the heat perception and perception of vulnerability of an elderly population in Germany and the coping strategies during episodes of heat used by an elderly population in Germany.	Cross-sectional design	Urban: Cologne (1.086 million); large cities	Germany	University Hospital Bonn	Age: 65 and over Health: n/i	258 people	Develop future intervention plans based on the information obtained

Table 2. *Cont.*

Authors and Year	Objective	Temporal Focus	Study Area/Scale	Country	Responsible	Inclusion Criteria	Sample Size	Future Lines
Malmquist et al., 2022 [74]	To explore elders' subjective experiences of heat impacts and adaptive strategies.	Cross-sectional design	Urban: medium-sized cities in Sweden	Sweden	Linköping University	Age: 61 and over Health: n/i	19 people	Further research on the subject
Loughnan et al., 2013 [75]	To explore adaptations in a heat-exposed older rural community.	Cross-sectional design	Rural: without information on the place of study and scale	Australia	Monash University	Age: 55 and over Health: n/i	26 people	Development of heat adaptation strategies
Lou et al., 2021 [76]	To provide theoretical support to the government and select practical and effective intervention measures to protect rural dwellers from high temperatures in a time of rapid climate change.	Cross-sectional design	Rural: rural areas near Xinyi; Agrarian settlements (towns and villages)	China	Nanjing University	Age: 50 years and older Health: n/i	44 people	Promote education-focused policies for older people to better cope with heatwaves

n/i: No information. Source: Based on this systematic review. Own elaboration.

Table 3. Methodology used in the different studies selected for the systematic review.

Authors and Year	Methodology	Instruments	Variables	% Type of Study		
				Mixed Method	Quantitative Method	Qualitative Method
Mukhopadhyay & Weitz, 2022 [60]	Mixed Method	Questionnaires, interviews, monitoring of the person's situation, and data collection of the climate situation	Age, place of residence, temperatures, humidity, feeling of warmth	41.2%	29.4%	29.4%
Weitz et al., 2022 [61]	Mixed Method	Questionnaires, interviews and direct observation	Age, sex, marital status, educational level, type of housing, sleep quality, access to centres with cooling systems and general resources,			
Larrieu et al., 2008 [62]	Quantitative Method	Phone surveys	Perceived morbidity and objective morbidity			
Abrahamson et al., 2009 [63]	Qualitative Method	Semi-structured interviews	Age, health status and place of residence			

Table 3. *Cont.*

Authors and Year	Methodology	Instruments	Variables	% Type of Study		
				Mixed Method	Quantitative Method	Qualitative Method
Wolf et al., 2010 [64]	Qualitative Method	Semi-structured interviews	Age, place of residence and share capital			
White-Newsome et al., 2011 [65]	Mixed Method	Monitoring of behaviours and analysis of meteorological data.	Age, place of residence and housing conditions			
Banwell et al., 2012 [66]	Qualitative Method	Interviews and focus groups	Age, income level, place of residence and access to support			
Bittner & Stößel, 2012 [67]	Qualitative Method	Semi-structured interviews	Age and place of residence			
Hansen et al., 2014 [68]	Quantitative Method	Surveys	Age and place of residence			
Wanka et al., 2014 [69]	Quantitative Method	Surveys	Age, education, housing conditions			
Lindemann et al., 2018 [70]	Quantitative Method	Surveys	Age, place of residence, need for formal support			
Nunes, 2018 [71]	Mixed method	Semi-structured interviews and census database analysis	Age, sex, marital status, living arrangements, education level, financial status			
Eady et al., 2020 [72]	Mixed method	Surveys and interviews	Risk factors, access to resources, perceptions of risk, protective behaviours, use of resources and perceptions of gaps in resources for seniors.			
Kemen et al., 2021 [73]	Quantitative Method	Surveys	Age, sex, educational level, housing, cohabitation.			
Malmquist et al., 2022 [74]	Qualitative Method	Semi-structured interviews	Age, sex, perceived heat, heat stress, and adaptive behaviour			
Loughnan et al., 2013 [75]	Mixed Method	Interviews, focus groups and analysis of meteorological data	Age, place of residence			
Lou et al., 2021 [76]	Mixed Method	Questionnaires and direct intervention with participants	Temperature, age, sex, economic and educational level, health status, psychological status and housing			

Source: Based on this systematic review. Own elaboration.

Table 4. Socio-demographic and health variables addressed in the different studies selected for this systematic review.

Author and Year	Sociodemographic								Health			
	Age		Gender		Educational and Socioeconomic Level		Living Alone		Health Status		Functional and Cognitive Problems	
	Urban	Rural	Urban	Rural	Urban	Rural	Urbar	Rural	Urban	Rural	Urban	Rural
Mukhopadhyay & Weitz, 2022 [60]	70 people between 60 and 69 years old; 60 people aged 70 and over	115 people between 60 and 69 years old; 65 people aged 70 and over	74.6% of women	50.5% of women	34.6% people without primary education	32.8% people without primary education	No	No	37.7% totally inactive people	20.6% totally inactive people	No	No
Weitz et al., 2022 [61]	Average age: 68.9 years	Median age: 67.9 years	74.6% of women	50.5% of women	34.6% people without primary education	32.8% people without primary education	4.6%	1.7%	37.7% totally inactive people	20.6% totally inactive people	No	No
Larrieu et al., 2008 [62]	Median age: 78.3 years		63.5% women		n/i		34.8%		n/i		No	
Abrahamson et al., 2009 [63]	Median age: 80.5 years		56.1% female		n/i				n/i		n/i	
Wolf et al., 2010 [64]	n/i		n/i		n/i		n/i		n/i		n/i	
White-Newsome et al., 2011 [65]	n/i		n/i		n/i		n/i		n/i		n/i	
Banwell et al., 2012 [66]	20 people aged 65 and over		More than 75% were women		100% of household incomes of less than AUD 30,000 per annum		No		No		No	
Bittner & Stößel, 2012 [67]	Median age: 82.1 years		60% women		No		30%		No		No	

Table 4. *Cont.*

Author and Year	Sociodemographic						Health			
	Age		Gender		Educational and Socioeconomic Level		Living Alone		Health Status		Functional and Cognitive Problems	
	Urban	Rural	Urban	Rural	Urban	Rural	Urbar	Rural	Urban	Rural	Urban	Rural
Hansen et al., 2014 [68]	29.3% between 65 and 69 years old		54.3% women		28.2% less than USD 20,000 annually		No		75% self-perceived health as excellent, very good or good		No	
Wanka et al., 2014 [69]	Mean age: 74.1 years		65.6% women		No		No		No		No	
Lindemann et al., 2018 [70]	Mean age: 80.9 years		84% female		No		No		No		No	
Nunes, 2018 [71]	Mean age: 75.1 years		63% women		No		58%		No		No	
Eady et al., 2020 [72]	Mean age: 71.7 years		63.9% female		8.2% less than USD 5000 annually		48.8%		No		No	
Kemen et al., 2021 [73]	n/i		n/i		n/i		n/i		n/i		n/i	
Malmquist et al., 2022 [74]	s/n		63.1% women		No		No		No		No	
Loughnan et al., 2013 [75]		Median age: 72.5 years		42% women		No		32%		Good self-perceived health; Body mass index: 28.7 kg/m^2		No
Lou et al., 2021 [76]		n/i		n/i		n/i		n/i		n/i		n/i

n/i: No information. Source: Based on this systematic review. Own elaboration.

Table 5. Physical environment addressed in the different studies selected for this systematic review.

Author and Year	Physical Environment															
	Housing										Neighbourhood					
	Typology		Design and Materials		Equipment		Services		Adaptations Made and Proposed		Equipment		Services		Climate Shelters	
	Urba	Rura	Urba	Rura	Urba	Rura	Urban	Rural	Urba	Rura	Urban	Rural	Urba	Rura	Urba	Rural
Mukhopadhyay & Weitz, 2022 [60]	Yes	Yes	Yes	Yes	Yes	Yes	Reduced accessibility to drinking water	Greater accessibility to drinking water	No	No	Fewer areas to abate high temperatures	More areas to cope with high temperatures	No	No	No	No
Weitz et al., 2022 [61]	No	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	No
Larrieu et al., 2008 [62]	No		Yes		Yes		No		No		No		Yes		No	
Abrahamson et al., 2009 [63]	No		No		Yes		No		No		Yes		Yes		No	
Wolf et al., 2010 [64]	Yes		No		Yes		No		No		No		No		No	
White-Newsome et al., 2011 [65]	Yes		No		Yes		Yes		No		No		No		No	
Banwell et al., 2012 [66]	Yes		Yes		Yes		Yes		No		Yes		Yes		No	
Bittner & Stößel, 2012 [67]	No		No		No		No		No		No		Yes		No	
Hansen et al., 2014 [68]	Yes		No		Yes		No		No		Yes		Yes		No	
Wanka et al., 2014 [69]	No		No		Yes		No		No		Yes		No		No	
Lindemann et al., 2018 [70]	Yes		No		No		No		No		No		No		No	
Nunes, 2018 [71]	No		No		Yes		Yes		No		Yes		Yes		No	
Eady et al., 2020 [72]	No		No		Yes		Yes		No		No		Yes		No	
Kemen et al., 2021 [73]	Yes		No		Yes		Yes		No		No		Yes		No	
Malmquist et al., 2022 [74]	Yes		No		Yes		No		No		Yes		Yes		No	
Loughnan et al., 2013 [75]		No		Yes		Yes		No		Yes		Yes		Yes		No
Lou et al., 2021 [76]		No		No		Yes		No		No		No		No		No

Source: Based on this systematic review. Own elaboration.

Table 6. Social environment addressed in the different studies selected for this systematic review.

Author and Year	Social Environment									
	Type of Help (Grooming and Personal Care, Meal Preparation, House Cleaning, and Accompaniment and Outings)		Intergenerationa Solidarity		Participation		Formal Support Network		Informal Support Network	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Mukhopadhyay & Weitz, 2022 [60]	Increased access to support	Reduced access to support	No	No	No	No	No	No	No	No
Weitz et al., 2022 [61]	No	No	No	No	No	No	No	No	No	No
Larrieu et al., 2008 [62]	Yes		No		No		Yes		Yes	
Abrahamson et al., 2009 [63]	Yes		No		No		Yes		Yes	
Wolf et al., 2010 [64]	No		Yes		Yes		No		Yes	
White-Newsome et al., 2011 [65]	No		No		No		No		No	
Banwell et al., 2012 [66]	Yes		No		Yes		Yes		Yes	
Bittner & Stößel, 2012 [67]	Yes		No		Yes		Yes		Yes	
Hansen et al., 2014 [68]	Yes		No		Yes		No		No	
Wanka et al., 2014 [69]	No		No		No		No		No	
Lindemann et al., 2018 [70]	Yes		No		Yes		Yes		Yes	
Nunes, 2018 [71]	Yes		No		Yes		Yes		Yes	
Eady et al., 2020 [72]	Yes		Yes		No		Yes		Yes	
Kemen et al., 2021 [73]	Yes		No		Yes		Yes		Yes	
Malmquist et al., 2022 [74]	Yes		No		No		Yes		Yes	
Loughnan et al., 2013 [75]		Yes		No		No		No		No
Lou et al., 2021 [76]		No		No		No		Yes		No

Source: Based on this systematic review. Own elaboration.

Table 7. Risk management addressed in the different studies selected for this systematic review.

Author and Year	Risk Management			
	Knowledge and Effectiveness of Heat Warning Systems		Adoption of Protective Measures	
	Urban	Rural	Urban	Rural
Mukhopadhyay & Weitz, 2022 [60]	No	No	Resting, drinking water, moving to cooler places, using fans, reducing domestic and economic activities, modifying social activities, changing clothes, and eating food	Resting, drinking water, moving to cooler places, using fans, reducing domestic and economic activities, modifying social activities, changing clothes, and eating food
Weitz et al., 2022 [61]	No	No	Promote the use of air conditioning and greater hydration	Use of air conditioning and increased hydration
Larrieu et al., 2008 [62]	No		Cool off with cold baths and change clothes	

Table 7. *Cont.*

Author and Year	Risk Management			
	Knowledge and Effectiveness of Heat Warning Systems		Adoption of Protective Measures	
	Urban	Rural	Urban	Rural
Abrahamson et al., 2009 [63]	No		Encourage the use of air conditioning	
Wolf et al., 2010 [64]	No		Encourage the use of air conditioning	
White-Newsome et al., 2011 [65]	No		Encourage the use of lighter clothing, showering and going outside or in the basement	
Banwell et al., 2012 [66]	No		Encourage personal cooling techniques, modifications in daily activity patterns, adjustment of eating habits, and near-universal use of air conditioning	
Bittner & Stößel, 2012 [67]	No		Promote hydration, close windows during the hottest hours, and increase use of air conditioning at night	
Hansen et al., 2014 [68]	No		Encourage the use of air conditioning	
Wanka et al., 2014 [69]	No		Increasing fluid intake and taking cold showers, staying home and closing curtains, or swimming	
Lindemann et al., 2018 [70]	No		Wear lighter clothing and increase fluid intake	
Nunes, 2018 [71]	No		Encourage lifelong learning, to improve isolation and participation in local activities	
Eady et al., 2020 [72]	To promote comprehensive extreme heat response strategies, such as increasing risk awareness, modernising infrastructure, and improving protective measures and response systems.		Promote the use of air conditioning and ventilation in the home	
Kemen et al., 2021 [73]	No		Promote personal cooling strategies, adequacy of activities of daily living, and measures of adaptation of the home	
Malmquist et al., 2022 [74]	No		Limit heat exposure by using fans and ventilation and staying indoors	

Table 7. *Cont.*

Author and Year	Risk Management			
	Knowledge and Effectiveness of Heat Warning Systems		Adoption of Protective Measures	
	Urban	Rural	Urban	Rural
Loughnan et al., 2013 [75]		To raise awareness and ensure timely responses to heat-related challenges.		Cross-ventilate by opening windows and doors, program behaviour to avoid heat and avoid activities that increase temperature,
Lou et al., 2021 [76]		No		Increased use of air conditioning

Source: Based on this systematic review. Own elaboration.

Table 8. Risk of bias of the studies selected for this systematic review.

Authors and Year	Risk of Bias			
	Insufficient Information on the Characteristics of the Participants	Insufficient Information on the Instruments and Measures Implemented	Insufficient Information on the Results Associated with the Study	Total
	Degree	Degree	Degree	Degree
Mukhopadhyay & Weitz, 2022 [60]	Low	Moderate–low	Moderate	Moderate–low
Weitz et al., 2022 [61]	Low–moderate	Moderate–low	Moderate	Moderate–low
Larrieu et al., 2008 [62]	Low–moderate	Moderate–low	Low–moderate	Low–moderate
Abrahamson et al., 2009 [63]	Low–moderate	Moderate–low	Moderate–low	Moderate–low
Wolf et al., 2010 [64]	Moderate–high	Moderate	Low–moderate	Moderate
White-Newsome et al., 2011 [65]	Moderate–high	Moderate	Low–moderate	Moderate
Banwell et al., 2012 [66]	Moderate–low	Low–moderate	Low–moderate	Low–moderate
Bittner & Stößel, 2012 [67]	Moderate–low	Low–moderate	Moderate–low	Moderate–low
Hansen et al., 2014 [68]	Low–moderate	Moderate–low	Low–moderate	Low–moderate
Wanka et al., 2014 [69]	Moderate–low	Low–moderate	Low–moderate	Low–moderate
Lindemann et al., 2018 [70]	Low–moderate	Moderate	Moderate–low	Moderate–low
Nunes, 2018 [71]	Low–moderate	Low	Low–moderate	Low–moderate
Eady et al., 2020 [72]	Low–moderate	Low	Low–moderate	Low–moderate
Kemen et al., 2021 [73]	Low–moderate	Low–moderate	Low–moderate	Low–moderate
Malmquist et al., 2022 [74]	Low–moderate	Low–moderate	Low–moderate	Low–moderate
Loughnan et al., 2013 [75]	Moderate–low	Moderate–low	Low–moderate	Moderate–low
Lou et al., 2021 [76]	Moderate	Moderate–high	Moderate	Moderate–low
Total	Low–moderate	Moderate–low	Moderate–low	Moderate–low

Source: Based on this systematic review. Own elaboration.

2.5. Summary of the Methodology

The studies were presented in narrative form, which is an appropriate method to evaluate the data of each article in a visual and simple way. This narrative summary provides an overview of the results of the selected studies, structured according to the general characteristics of each paper, the methodology, the content and the approach to the different variables proposed (Tables 2–7).

3. Results

3.1. Included Studies

The initial search yielded a total of 4991 potential articles. The post-screening stages of title, abstract and keyword checking reduced the number of records to a total of 1649 articles, which were subsequently reduced to 414. This process resulted in the exclusion of 1158 manuscripts. The remaining 414 articles were subjected to a thorough full-text review against the established inclusion and exclusion criteria. As a result of this process, 17 studies were included in this review (Figure 1). Furthermore, this review is dominated by a multidisciplinary approach, with articles written by authors from the health (41.2%) [62,63,67,68,70,72,76], social (35.3%) [60,61,64,66,71,74] and territorial, (geography, urban planning, territorial planning, and civil engineering), (23.5%) [65,69,73,75] sciences.

As regards the geographical distribution of research, 52.9% is located on the European continent, namely, in France, the United Kingdom, Germany, Austria, Portugal and Sweden [62–64,67,69–71,73,74]. Similarly, 18.6% of studies are located in Australia [66,68,75] and 11.8% in India [60,61]. The remaining studies are in China [76], the United States [65] and Canada [72] (Figure 2). This diverse geographical distribution of studies enhances this systematic review.

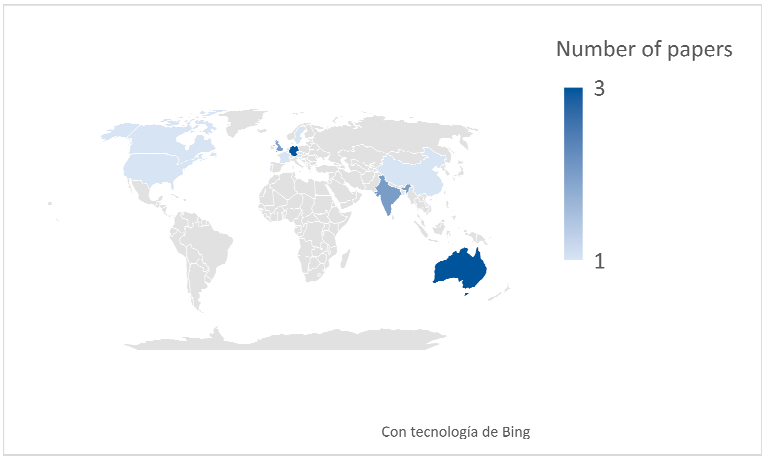

Figure 2. Geographical distribution of the analysed papers. Source: Based on this systematic review. Own elaboration.

All articles adopted a cross-sectional perspective and used primary sources of information and/or a combination of primary and secondary sources.

Most of the articles analysed (76.4%) focused exclusively on urban settings [62–74]. Similarly, 11.8% of the selected articles focused only on rural settings [75,76], while 11.8% used a comparative approach between urban and rural areas [60,61]. Also, in terms of the scale of the settings analysed in terms of population size, large cities (between 1 and 10 million inhabitants) [63,64,66,68,69,73] and small cities (<500,000 inhabitants) [63,64,67,72] predominated. In addition, 17.6% of the studies focused on medium-sized cities (between 500,000 and 1,000,000 inhabitants) [65,71] and 11.8% on megacities (>10 million inhabitants) [60,61].

All articles analysed heatwaves and their effects on the elderly population. However, 41.2% of the studies defined the elderly population as those aged 65 years or older [62,65,66,68,69,71,73]. About 29.4% of the studies defined the older population as those aged 60 years or older [60,61,67,70,74]. Similarly, 11.8% set the age limit at 50 years or older [72,76]. Similarly, 11.8% set the age limit at 72 years or older [63,64]. Only 5.9% set the age limit at 55 years or older [75]. The sample size is available for 100% of the studies analysed (Table 2). The average number of participants in the available papers is 326. In addition, the designs of the included studies were largely determined by the available

human and financial resources, which were entirely the responsibility of the universities and research centres.

To provide an overview of the selected articles, a word cloud of the titles of the analysed articles is presented (Figure 3, in which terms such as urban, rural, elderly, heat predominate.

Figure 3. Word cloud with the titles of the analysed articles. Source: Based on this systematic review. Own elaboration.

3.2. Strategies, Instruments, and Measurements Used

In terms of methodology, 41.2% used mixed models combining quantitative and qualitative methods (Table 3) [60,61,65,71,72,75,76]. Quantitative methods were chosen by 29.4% of the selected manuscripts [62,68–70,73]. Similarly, 29.4% of the studies analysed used qualitative methods [63,64,66,67,74]. Furthermore, urban studies predominantly applied quantitative methods [62,68–70,73]. In contrast, mixed methods predominated in rural studies [75,76]. In addition, comparative studies (urban and rural) handled mixed methods [60,61].

A portion of the studies employed primary sources with surveys and questionnaires (23.5%) [62,68–70,73] and interviews (23.5%) [63,64,67,71,72,74]. The remaining studies (17.6%) combined both techniques [61,72,76]. In the articles that retained both primary and secondary sources of information (23.5%) [60,65,71,75], the latter focused on meteorological databases [60,65,75] and census databases [71].

Regarding the type of instrument applied in the different articles, only one of the selected studies refers to the use of these instruments, namely, the multiple deprivation index [63].

In the selected articles, the terms heatwaves (82.4%) [60–70,72–74] and extreme heat (17.6%) [71,75,76] predominate.

3.3. Sociodemographic Variables

The mean age of the participants in the different studies was reported in 70.6% of the manuscripts [53,60–62,66–72,75]. Gender was also reported in 76.5% of manuscripts [60–63,66–72,74,75]. In these articles, the proportion of women was higher than that of men, except for one study [75]. Only one paper [60] analysed data on perceptions of vulnerability and adaptation from a gender perspective.

As for the level of education or socio-economic status, this variable appeared in 29.4% of the articles [60,61,66,68,72]. However, 40% of these articles focused on educational level [60,61] and 60% on annual income [66,68,72]. Consequently, no studies from rural areas considered this variable. Notably, studies in India found lower levels of education in urban areas than in rural areas [60,61].

The proportion of studies that looked at living alone was 35.3%. Of these, 35.3% were conducted in urban areas and 35.3% in rural areas [61,62,67,71,72,75]. Among these, 34.7% of participants lived alone, with the majority living in urban areas.

3.4. Health

Only 23.5% of the reviewed articles [60,61,68,75] addressed the health status of the subjects. Of these, 11.8% of the studies reported that the predominant perceived health status was good [68,75]. However, in 11.8% of the selected studies, perceived health status was replaced by daily activity level [60,61], with minimal activity level being predominant. Regarding location, self-perceived good health was more common in urban areas than in rural areas. It should also be noted that none of the studies investigated the potential functional and cognitive difficulties of older participants.

3.5. Physical Environment

Regarding dwelling, several variables were identified, including typology, design and materials, equipment, services and adequacy. Typology, such as blocks of flats and single-family houses, is a variable analysed in 47.1% of the studies [60,64–66,68,70,73,74]. This variable is particularly prevalent in articles from urban environments, as it was not considered in any rural study and only one comparative study was carried out. There was also a single study that looked at sheltered housing for older people [70].

Comparative studies looked at housing design and materials, such as the number of rooms, the design of the kitchen or the type of bathroom available [60,61]. However, only two urban studies considered this aspect [62,66], whereas 50% of the rural articles considered this factor [75]. None of the studies considered the analysis of housing materials in terms of insulation and thermal comfort.

The availability of housing equipment, including air conditioning, blinds and curtains, was examined in 88.2% of the articles [60–66,68,69,71–76]. A lower prevalence of equipment, such as the use of air conditioning, was observed in rural dwellings compared to urban dwellings.

In terms of dwelling services such as electricity and drinking water, these were present in 38.5% of urban studies [65,66,71–73]. However, no rural study examined this variable. Furthermore, 50% of the comparative studies included this variable [60]. Finally, the variable of adaptations made to the dwelling, such as bathroom renovations and the purchase of heating equipment, is an understudied variable. Only 11.8% of all studies examined this variable [60,75]. It is striking that none of the urban studies examined this variable.

Regarding the neighbourhood, the variable's location, residential density, land use, access to equipment and services, and climate shelters were investigated. Thus, neighbourhood amenities such as green spaces and local shops were the subject of 47.1% of manuscripts [60,63,66,68,69,71,74,75]. A higher prevalence of this variable was observed in studies conducted in urban environments and, to a lesser extent, in rural areas. As a result, access to green space was related to residential density and land uses, and it was identified as a highly effective and sustainable approach to address the problems of pollution and heat islands associated with extreme heat in the urban areas [69]. In this context, the issue of access to local shops was highlighted as a major challenge in rural areas, with implications for food supply [60].

Neighbourhood services such as health and social services and public transport were more common in urban studies (69.2%) [62,63,66–68,71–74]. In contrast, only one rural study analysed them [75], highlighting the problems of access to these services for the community. It is also interesting to note that none of the studies identified and analysed possible shelters from extreme heat.

3.6. Social Environment

The social environment dimension was approached through the variables of social participation, formal and informal support networks, access to help and intergenerational solidarity in the face of heatwaves. Social participation of older people, such as social activities, was analysed in 53.8% of the urban studies [64,66–68,70,71,73]. This variable was not present in the rural studies. Similarly, informal support from family and friends was analysed in 61.5% of the urban studies [62–64,70–74]. In addition, formal support from institutions was reported in 53.8% of urban studies [62,63,70,71,73,74] and in all rural

studies [75,76]. Similarly, the type of assistance provided, including personal care and grooming, meal preparation, housework and accompaniment on outings, was included in 70.6% of studies [60,62,63,66–68,70–75]. This variable was addressed in 76.9% of urban studies [62,63,66–68,70–74] and in 50% of rural studies [75]. Finally, intergenerational solidarity was discussed in only two of the studies, both in urban areas [64,72].

3.7. Risk Management

The risk management dimension was analysed using the variables of adoption of protective measures and heat warning systems [33,34]. Accordingly, all studies examined the implementation of possible protective measures, including the use of air conditioning, home ventilation and personal cooling strategies (such as changes in clothing, hydration and diet). The use of air conditioning and personal cooling measures is emphasised in urban settings, while home ventilation (opening windows) is emphasised in rural settings. In contrast, only two studies (11.8%) analysed the knowledge and effectiveness of heat warning systems. These included promoting awareness, increasing knowledge, ensuring timely responses to heat and improving infrastructure [72,75].

3.8. Type and Degree of Risk of Bias in Results

According to the methodology described in the Cochrane Handbook [77], the studies selected for this systematic review (Table 8) were found to have some degree of bias. A moderate-to-high risk of bias related to the possible lack of information on participant characteristics was observed in all selected studies. This was demonstrated by the fact that 11.8% of the studies did not provide clear information on the age of the participants [64,65] (Table 8). Regarding the selection of participants, 23.5% of the studies provided specific information on the selection process [70–73]. These studies were concentrated in urban areas. In addition, 23.5% of the studies reported a lack of information about the instruments and measurements used with the participants [64,65,70,76]. Finally, 17.6% of the articles identified a lack of evidence on outcomes related to the effectiveness of the intervention [60,61,76].

Only four of the reviewed studies provided adequate information on the selection of participants [70–73]. The most common techniques used were snowball sampling, purposive sampling or convenience sampling.

4. Discussion

The findings of this systematic review demonstrated the limited and dispersed knowledge on the planning and management of urban and rural environments and its implications for adaptation strategies for ageing populations at risk of heatwaves. A multidisciplinary approach was a prominent feature of the studies reviewed, with a clear predominance of health, social and territorial science (geography, urban planning, territorial planning, and civil engineering) disciplines. In addition, the studies conducted in European countries, Australia and India were found to be of higher quality. Furthermore, theoretical and methodological gaps were identified, and relevant multidisciplinary approaches, such as environmental gerontology and climate gerontology, were omitted [30,78]. Precisely, these approaches make it possible to identify novel analytical frameworks for examining the relationship between ageing and the evolution of the physical and social environment in the face of a climate change scenario [49,79,80].

This selection of studies revealed a lack of consensus on the precise definition of the term ‘heat wave’, a finding that is consistent with other reviews [6,81]. In addition, the sample highlighted the potential economic and health risks associated with extreme heat, particularly for vulnerable populations, including the elderly. This finding aligns with previous research [82].

The studies reviewed involved people under 70, and socio-demographic characteristics and health status are not well known. Consequently, none of the studies focused on people aged 80 years or older, who typically have reduced functional and cognitive abilities and are more vulnerable to heatwaves [83,84]. In addition, a lack of gender perspective

was evident in the selected studies. In this context, the literature highlights the need to study climate adaptation in older people from a gender perspective, as older women are more vulnerable [85]. There is also a lack of data on the socio-economic characteristics of the study population. However, the available information reflects a low socio-economic and educational level of this population group, which prevents comparisons between urban and rural environments. In this regard, it has been observed that older people with low incomes and informal jobs are more exposed to thermal comfort problems in housing and energy poverty in the face of environmental hazards such as extreme heat [86]. Moreover, only a third of the studies examined social isolation and most focused on urban areas. It is important to note that the lack of relevant socio-demographic details, such as socioeconomic status or social isolation, limits an approach to the vulnerability of older people to temperature extremes, as highlighted in the literature [87,88].

The examined studies showed a paucity of information on health status, functional and cognitive problems. The available evidence suggested that perceived health status was generally positive, with the highest levels of satisfaction observed in urban areas. This is consistent with other studies showing that older people in rural areas are more susceptible to chronic disease due to a more hostile environment [59]. Indeed, in rural communities, self-rated health is associated with passivity and memory [89]. However, some studies have observed the use of daily activities as an indicator of health status, with a higher proportion of inactive people in urban areas [60,61]. In addition, no studies addressed functional or cognitive problems. It can be concluded that the relevant health variables of the participants were not given sufficient attention, despite their importance for understanding the vulnerability and adaptation of this population to heatwaves [90]. Indeed, thermoregulatory limitations and cognitive impairment in older people have been shown to have a direct impact on their ability to adapt to extreme heat [91].

The papers reviewed paid more attention to housing typology and equipment and, to a lesser extent, to design and materials, services and environmental adaptations made and proposed. Also, a comparison between urban and rural areas is not possible based on the available data. However, it is important to note that the existing literature suggests that housing in urban slums and rural areas, particularly in developing countries, is more precarious and makes older people more vulnerable to heatwaves [7,92]. The sample also showed a weakness in potential correlations between housing characteristics and relevant participant variables, such as health and social isolation.

Housing and neighbourhood are relevant factors in the ageing-in-place process [93,94]. Indeed, ageing-in-place includes the desire to age in familiar surroundings as well as adaptive housing modifications for ageing, urban regeneration strategies and climate adaptation strategies [95]. However, the selected studies did not provide relevant data on housing characteristics that would allow an assessment of the state of housing and its possible implications for ageing at home [96]. Consequently, the literature emphasises that most older people express a preference for ageing in their own homes [97]. However, they are often unaware of possible adaptations that could be made to their homes to increase resilience to heatwaves [98].

At the neighbourhood level, more attention was paid to access to services (social, health and public transport) than to facilities (green spaces and local shops), especially in urban areas. In this regard, green spaces play an important role in mitigating the effects of heat islands and heatwaves in urban areas [99,100]. However, the results indicated that residential density and land uses condition the location and access to green spaces. Precisely, different publications have highlighted the importance of urban planning in controlling residential density and responsible management of land use, as well as in promoting green spaces in the face of extreme heat [33,34].

The studies also reflected the problem of access to services in rural areas, in line with the existing literature on this issue [101]. However, no studies included climate shelters, despite their growing importance in the literature [102]. Similarly, no studies were found that addressed the relationship between older people's perceptions of safety and

the characteristics of the urban built environment, despite evidence in the literature [103]. Other evidence suggests that these spaces may influence health, risk of social isolation and access to support networks in emergency situations [104].

In addressing the social environment, the selected studies placed particular emphasis on the nature of formal and informal support and support networks in relation to social participation and intergenerational solidarity. Thus, in urban settings, it was found that the most common type of support analysed was personal care and accompaniment when going out, which was mainly provided by the informal support network, such as family and friends. In rural environments, however, there was a lack of informal support, with formal and institutional support being prioritised. In this context, the lack of informal support can be attributed to the prevalence of social isolation, as shown by numerous studies [105]. In contrast, social participation and intergenerational relations were not considered in the rural studies, while these variables were only partially addressed. It is evident that intergenerational relations are a crucial aspect of support and accompaniment that has not been sufficiently investigated in the selected studies despite its importance in the existing literature [106]. It is also noteworthy that identity and place attachment have not been addressed, despite the possible implications for heat adaptation [107]. Indeed, other studies have shown that place attachment (neighbourhood) plays a key role as an environment for promoting social interaction and support in times of need or emergency in the face of potential anthropogenic or climatic hazards [108].

Risk management was addressed through the adoption of protective measures and heat warning systems. In urban areas, the most common protective measures were the use of air conditioning and personal cooling measures, in line with other studies [109]. However, the adoption of protective measures, such as the use of air conditioning, has been questioned because of the costs and risks involved, which increase social inequalities and the marginalisation of disadvantaged communities [110]. In addition, heat warning systems in these areas have highlighted the need to promote comprehensive strategies for responding to extreme heat, such as raising awareness of risks, improving infrastructure, and enhancing protective measures and response systems. In this regard, in rural areas, ventilation of dwellings was highlighted as the main protective measure, and among heat warning systems, raising awareness and ensuring timely responses to heat-related challenges were highlighted, as indicated by the available scientific evidence [111]. In this context, the selected studies did not address issues of integrating urban design and planning with energy efficiency or the adequacy of regulatory and policy frameworks in the face of extreme heat [112].

In the selected studies, the different scales of the environments analysed in terms of population size, such as megacities, large cities, medium-sized cities, small cities, towns and villages, constitute a plurality of environmental realities that limit possible comparisons and make it difficult to extrapolate proposals for planning and managing urban and rural environments in the face of the climate crisis. In this sense, the literature highlights the importance of understanding the influence of geographical scales in territorial planning and the design of climate adaptation strategies [113].

Regarding question (1) (Which setting (urban or rural) best supports older adults' adaptation to heatwaves?), the results of this review do not allow us to identify which setting has a greater influence on older people's adaptation to heatwaves. In this regard, the lack of consensus on the identification and analysis of relevant variables related to health and the physical and social environment, together with the paucity of data, prevents a meaningful comparison between these settings. This may be related to the lack of consensus expressed in other publications [42,43].

With respect to question (2) (Which physical and social factors in urban and rural settings determine older adults' adaptation to heatwaves?), the selected studies indicate that urban and rural environments influence the adaptation strategies of older adults to heatwaves through the adaptation of the physical environment of the home (design, materials, equipment) and the neighbourhood (green spaces, residential density, land uses),

the social environment (support network and type of assistance) and risk management (protection measures and heat alert systems).

Regarding question (3) (To what extent do older adults' perceptions of adaptation to heatwaves differ between urban and rural settings?), when considering the issue of different perceptions of vulnerability and adaptation to heat depending on the environment, it can be observed that urban older people perceive heat stress as a major constraint on the performance of daily activities compared to those living in rural areas. This may be related to the experience and normalisation of climate impacts in rural areas [114].

It is important to note that the lack of data on risk profiles, such as older women, octogenarians, women living alone, and women with functional and cognitive impairments (disabled and dependent), hinders the ability to accurately assess social vulnerability to heatwaves [115]. In addition, the lack of information on the physical and social environment limits the assessment and design of adaptation strategies for older people and their communities in the context of heatwaves [29].

The findings of this review highlight important knowledge gaps and the identification of prevailing multidisciplinary approaches to address the impact of the physical and social environment on older people's adaptation to heatwaves in rural and urban areas. The evidence also contributes to the design and evaluation of heat warning systems and the adoption of protective measures, as well as intervention programmes and public policies in health, social services, housing, urban planning and risk management in the face of increasing extreme temperatures [41]. In this context, the need to integrate this knowledge into programmes for age-friendly cities and communities in the face of the challenge of climate change has been highlighted [116].

Limitations

This systematic review has attempted to identify and address the biases inherent in the research methodology. However, the interpretation of the results is subject to certain limitations, including the non-inclusion of articles indexed in other bibliographic databases and the possible loss of an important reference due to an error by the participating researchers. In addition, the lack of reviews examining the impact of heatwaves in urban and rural settings and the lack of consideration of the influence of the physical and social environment necessitated the application of broad inclusion criteria. However, this approach resulted in the selection of studies of moderate to low quality. In addition, a meta-analysis was not chosen due to the heterogeneity of the retained references, characterised by the diversity of data sources, variables analysed and insufficient information available to perform such an analysis.

5. Conclusions

The results of this review showed that there is limited knowledge about the impact of urban and rural environments on older people's coping strategies with heatwaves. A multidisciplinary approach predominated in the selected studies, mainly from the health, social and territorial sciences. In addition, interest in the topic was concentrated in European countries, Australia and India, with a lack of studies in developing regions such as Latin America and Africa. At the same time, the quality of the selected studies was rather low due to a lack of specific information on the characteristics of the research, such as the method of selection of participants.

In the sample analysed, urban and rural settings determine older adults' adaptation strategies to heatwaves through the adequacy of the physical environment of the dwelling (design, materials, equipment) and the neighbourhood (green spaces, residential density, land use), the social environment (support network and type of assistance) and local risk management (protective measures and heat warning systems). In this regard, residential density and land uses determine the location and access to green spaces, as well as adaptation to heatwaves.

At the individual level, adaptation to heatwaves is conditioned by age, gender, socioeconomic status, isolation and health status. Among the characteristics of the participants, a relatively higher presence of younger adults and older adults with lower socioeconomic conditions was observed, especially in urban and marginal rural areas of developing countries. Also, social isolation is an important vulnerability factor for one third of older adults in relation to heatwaves. In addition, most respondents reported good health perceptions despite a high proportion of inactive people in urban areas. As a result, there was a paucity of data on heatwave risk profiles, including older women, people living alone, and people with functional and cognitive disabilities.

Lack of consensus in the identification and analysis of relevant variables related to health dimensions and the physical and social environment, and limited data prevented comparison and identification of which environment (urban or rural) facilitated older people's adaptation to extreme heat. There were also differences in perceptions of vulnerability and adaptation to heat by environment, with urban older people being more vulnerable, particularly in developing countries.

It is proposed to encourage lines of research relating to the generation of knowledge about the implications of planning and management of urban and rural environments in climate adaptation strategies for the elderly. In this regard, research should be promoted on adaptation strategies to heatwaves for older people in urban and rural environments, based on the impact of the location, typology and characteristics of housing and neighbourhood, especially in developing regions. To this end, it is essential to promote theoretical and methodological consensus through a multidisciplinary approach. Other lines of research should promote the development of adaptive environmental strategies for groups at risk from heatwaves, such as people aged 80 and over, women, people with functional and cognitive problems, and those suffering from social isolation in rural and urban areas. Similarly, the development of research that explores the gender perspective in relation to heatwave adaptation strategies should be encouraged. It also calls for the development of studies that address the relationship between the environment and long-term care in the face of extreme heat risk. It also suggests that the relationship between identity and place attachment in ageing and its implications in a climate change scenario should be explored. Further evaluation and adaptation of the Age-Friendly Cities and Communities Programme to a climate warming scenario is also recommended. In addition, studies are proposed to evaluate heat warning systems and climate adaptation measures for older adults in urban and rural areas. The aim is to contribute to the development of comprehensive, direct and indirect action plans in which older people can minimise their physical and social risks to heatwaves and remain active citizens.

Climate change, urbanisation and population ageing are global challenges with significant social and environmental impacts at the local level. Therefore, any climate adaptation strategy must include a better understanding of the changing urban and rural environments in which we age, and their impact on resilience, security, and social and environmental justice. Indeed, the growing challenges of social inequality, exclusionary urbanism, rural depopulation and ageism require a greater degree of collective awareness, a firm commitment to intergenerational cooperation and solidarity, and the design of supportive, inclusive and climate-resilient environments.

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