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Investigating the relationship between heatwaves and falls: A systematic review protocol

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Abstract

Background: Heatwaves are becoming more frequent, intense, and prolonged due to climate change, posing a significant global public health risk. Most research on heatwaves has concentrated on mortality and morbidity from heat-related illnesses, while injury-related morbidity such as accidental falls remains underexplored. Falls are a leading cause of unintentional injury worldwide, particularly among older adults, and may be exacerbated by the physiological and cognitive stress imposed by extreme heat. However, the relationship between heatwaves and falls has not been systematically reviewed.

Aim: To conduct a scoping review of the existing literature to identify and synthesise current evidence on the association between extreme heat and falls across different populations and settings.

Methods: This review will follow PRISMA guidelines. Peer-reviewed primary studies in English examining associations between heatwaves and falls will be included. Searches will be conducted in Medline, CINAHL, Embase, Web of Science, and Scopus, with additional grey literature screening. Two to three reviewers will independently conduct study selection, data extraction, and quality appraisal using the Joanna Briggs Institute (JBI) critical appraisal tools. A narrative synthesis supported by descriptive statistics will be used to present findings.

Expected findings: The review is expected to highlight the extent of evidence linking heatwaves to falls, identify high-risk populations, and clarify the mechanisms by which extreme heat may contribute to fall risk. Findings will inform public health preparedness, aged-care strategies, and climate adaptation planning, addressing an underexplored dimension of the health impacts of heatwaves.

Main body

1 Background

Heatwaves are increasingly recognized as a major global threat to public health in the context of climate change. They are defined by the Intergovernmental Panel on Climate Change (IPCC) as prolonged periods of unusually high temperatures relative to local climatology (IPCC, 2022). According to the IPCC, heatwaves have grown in frequency, duration and intensity over the past five decades (IPCC, 2022). Globally, they are associated with substantially high levels of morbidity and mortality. This was evident during the 2003 European heatwave, which resulted in over 70,000 excess deaths (Robine et al., 2008) and the Russian heatwave that claimed around 55,000 lives (Shaposhnikov et al., 2014). Recent events have highlighted that even high-income countries are acutely vulnerable to extreme heat, as seen in the 2021 Pacific Northwest heatwave in North America (White et al., 2023).

The health consequences of heatwaves are multifaceted. Acute effects include dehydration, heat exhaustion, and heatstroke, while chronic impacts involve the exacerbation of pre-existing cardiovascular, respiratory, renal and mental health conditions (Kovats & Hajat, 2008). The World Health Organization (WHO) has identified older adults, individuals with chronic illnesses and socioeconomically disadvantaged populations as vulnerable groups who are disproportionately affected (WHO, 2021). Recent evidence also underscores the heightened vulnerability of aged-care residents during heatwaves, with increased risks of heat-related illness and mortality reported in residential care settings (Grootemaat, 2024). In addition, population-level studies have demonstrated elevated all-cause mortality among older adults and socioeconomically disadvantaged groups during recurrent heat events (Franklin et al., 2023). However, beyond these well documented outcomes, there is emerging evidence that heat also impairs cognitive performance concentration, physical coordination and balance (Gaoua, 2010). These mechanisms raise important concerns about an underexplored pathway: the contribution of heatwaves to unintentional injuries, especially falls.

Falls are a major global public health problem. According to the WHO, falls are the second leading cause of unintentional injury deaths worldwide, resulting in an estimated 684,000 deaths annually (WHO, 2021). Non-fatal falls are also a significant contributor to disability, particularly through fractures, traumatic brain injury and long-term loss of independence (Ambrose et al., 2013). Adults over 65 years experience the greatest burden, though falls affect all age groups (WHO, 2021). The risk factors of falls are multifactorial, including intrinsic factors such as muscle weakness, poor balance and chronic diseases, as well as extrinsic factors like environmental hazards (Ambrose et al., 2013). It is crucial to note that environmental stressors such as heatwaves may

exacerbate both intrinsic and extrinsic risks, creating conditions conducive to increased fall incidence.

There are several pathways that cause heatwaves to lead to falls and unintentional injuries. Physiological strain from heat can cause dizziness, dehydration, hypotension and fatigue, all of which compromise balance and stability (Kenny et al., 2010). Cognitive impairment under heat stress may reduce a person's capacity for attention and decision-making accuracy, which in turn increases the risk of accidents (Gaoua, 2010). Evidence from occupational health research supports these associations: high ambient temperatures are consistently linked to increased accident rates among outdoor workers, particularly in construction and agriculture (Varghese et al., 2018). While occupational settings provide clear examples, these mechanisms may extend more broadly to community-dwelling populations during heatwaves, where daily movements and activity occur in thermally stressful environments.

The impacts of heatwaves on falls remain an underexplored domain within environmental and public health research. Systematic reviews have highlighted the significant strain heatwaves place on emergency health services with increases in ambulance call-outs, emergency department visits and hospital admissions observed across multiple jurisdictions (Basu, 2009; Mason et al., 2022). State-wide analyses further demonstrate that ambulance call volumes can rise by over 10% during heatwaves, with effects persisting for days after the event (Mason et al., 2023). However, only a few studies have specifically considered injury or fall-related outcomes. For instance, Xiang et al. (2014) found that in Adelaide, a 1°C rise in maximum temperature was associated with about a 0.2% increase in work-related injury claims (Xiang et al., 2014). Other ecological and narrative reviews also show that unintentional injuries tend to increase during periods of extreme heat (Di Blasi et al., 2023; Otte im Kampe et al., 2016). These findings are preliminary but suggest that falls may constitute a hidden burden during heatwaves, warranting more systematic investigation.

Taken together, while heatwaves are well established as a driver of excess mortality and morbidity, their contribution to unintentional injuries and falls in particular remains insufficiently studied. Preliminary evidence suggests that heat-related impairments in cognition, balance, and physical coordination may increase the risk of falls, potentially amplifying the already significant global burden of falls. Given the aging global population, urbanisation, and climate change projections of more frequent and intense heatwaves, understanding the link between heat and falls is critical. This literature review, therefore, aims to identify and synthesise existing evidence on heatwaves and falls, addressing an important but underexplored intersection of climate and injury epidemiology.

Aim of the review

To conduct a scoping review of the existing literature to identify and synthesise current evidence on the association between extreme heat and falls across different populations and settings.

The review questions

1. What evidence exists on the relationship between exposure to heatwaves and the occurrence of falls, and what methodological or contextual gaps remain in the literature?
2. What populations are most vulnerable to heatwave-related falls according to the literature?

Methods

2 Inclusion and exclusion criteria

This review will adhere to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Tricco et al., 2018). To ensure methodological consistency and relevance to the research question, the following criteria will be applied:

Inclusion criteria

- *Peer-reviewed articles:* Only peer-reviewed publications will be included to maintain scientific quality and credibility.
- *Studies presenting primary data:* Eligible studies must provide original data, either quantitative or qualitative, to directly inform the review question.
- *Focus on heatwaves and falls:* Articles must explicitly examine heatwaves as an exposure and falls (or fall-related injuries) as an outcome.
- *English language:* Studies published in English will be included, reflecting feasibility considerations given the review team's language capacity.
- *No date restriction:* All years of publication will be considered to capture the evolution of evidence over time.

Exclusion criteria

- *Non-primary data sources:* Reviews, editorials, opinion pieces, and commentaries will be excluded, as they do not provide original data for synthesis.
- *Grey literature:* Reports, conference abstracts, and unpublished studies will be excluded to maintain a focus on peer-reviewed evidence with consistent reporting standards.
- *Case series and single case reports:* These will be excluded due to limited generalisability and potential for bias.
- *Non-English publications:* Excluded because translation resources are not available within the scope of this review.

P = The study population of interest

All population groups globally.

E = Exposure

Heatwaves

C = Comparator

Non-heatwave periods

O = Outcomes of interest

Unintentional falls requiring treatment from a health professional (e.g. ambulance, emergency department, hospitalisation, or General Practitioner) or leading to death

Search strategy and databases to be searched

A scoping review will be conducted to explore the relationship between heatwaves and fall-related health outcomes such as injuries, hospital admissions, emergency department presentations, and mortality. This review will follow the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) framework.

The objective is to map existing literature on the association between heatwaves and fall incidents across various populations and settings. Given the anticipated heterogeneity in study designs, populations, and outcome measures, a meta-analysis will not be feasible.

Databases

The literature search will be undertaken in the following databases:

1. Web of Science
2. Scopus
3. CINAHL Complete
4. MEDLINE (via Ovid)
5. Emcare (via Ovid)
6. Informit Databases

Search terms will include combinations of synonyms and MeSH terms related to:

- Exposure: heatwaves, high temperatures, extreme heat
- Outcome: falls, injuries, trauma, accidents, emergency visits, hospital admissions, death/mortality

Boolean operators (AND, OR) will be used to structure the search strategies. The review will include peer-reviewed studies published in English with no restriction on publication year to ensure comprehensive coverage. All identified references will be exported into EndNote for de-duplication and screening. The screening process will involve two phases:

- Title and abstract review, followed by
- Full-text review based on pre-specified inclusion and exclusion criteria.

Eligible studies must report on the relationship between heatwaves and fall-related health outcomes. Editorials, opinion pieces, and conference abstracts will be excluded. Data extraction will follow a structured format capturing author, year, country, study design, sample size, population, heat exposure metric, outcome definition, and main findings.

Findings will be synthesized narratively and presented in tables categorizing study characteristics and reported associations.

Study selection

After deduplication, the search results will be imported into the Rayyan online platform (<https://www.rayyan.ai/>) for eligibility screening. Title and abstract screening will be conducted independently and in a blinded manner by at least two reviewers. Studies that clearly do not meet the inclusion criteria will be excluded. Articles marked as “maybe” or identified as conflicts will progress to full-text assessment, along with those deemed potentially eligible at the initial stage. Full-text screening will also be performed by a minimum of two reviewers, with any disagreements resolved through discussion or adjudication by a third reviewer.

Data Extraction

A data extraction form will be developed in Microsoft Excel, drawing on guidance from the Cochrane Public Health Group (2011) and Joanna Briggs Institute (2011). For each included study, the following information will be recorded: country of study, year of publication, study objectives, design, setting, population characteristics, sampling and data collection methods, theoretical framework or hypotheses (if stated), definition of heatwave, fall-related outcomes, thematic area, key results and conclusions, as well as any reported policy or intervention recommendations. A section for reviewer comments will also be included to capture additional notes or observations.

Quality and risk of bias assessment

The methodological quality of included studies will be assessed using the Joanna Briggs Institute (JBI) Critical Appraisal tools, which provide structured checklists tailored to different study designs. Two reviewers will independently appraise each study using the appropriate JBI checklist, considering aspects such as the clarity of research aims, appropriateness of study design, adequacy of sampling methods, validity and reliability of measurement tools, completeness of data analysis, and transparency in reporting.

Each criterion score on the JBI checklist will be converted into percentage. Discrepancies between reviewers will be resolved through discussion, and a third reviewer will be consulted if consensus cannot be reached. The appraisal outcomes will not be used as an exclusion criterion; rather, they will inform the interpretation of the evidence base and highlight potential limitations in the included studies. A summary table

of appraisal results will be provided to give an overview of study quality across the review.

Data analysis

The extracted data will be synthesised using a descriptive and thematic approach consistent with scoping review methodology (Arksey & O'Malley, 2005; Peters et al., 2020). Study characteristics (e.g., country, year of publication, design, population, heatwave definition, and fall-related outcomes) will be summarised in tabular form and presented using frequencies and proportions where appropriate. A narrative synthesis will describe the scope and nature of existing evidence, with emphasis on study settings, definitions applied, methodological approaches, and key findings. Thematic coding will be used to identify common pathways linking heatwaves and falls, such as physiological mechanisms (e.g., dehydration, dizziness, heat stress), behavioural adaptations, and health system responses. Identified gaps in the literature will be highlighted to inform future research priorities.

Funding and conflict of interest

No external funding is sought or will be received for this study. The authors declare no conflict of interest.

Protocol references

- Ambrose, A. F., Paul, G., & Hausdorff, J. M. (2013). Risk factors for falls among older adults: a review of the literature. *Maturitas*, 75(1), 51-61. <https://doi.org/10.1016/j.maturitas.2013.02.009>
- Basu, R. (2009). High ambient temperature and mortality: a review of epidemiologic studies from 2001 to 2008. *Environmental Health*, 8(1), 40. <https://doi.org/10.1186/1476-069X-8-40>
- Di Blasi, C., Marinaccio, A., Gariazzo, C., Taiano, L., Bonafede, M., Leva, A., Morabito, M., Michelozzi, P., de' Donato, F. K., & Group, o. b. o. t. W. C. (2023). Effects of Temperatures and Heatwaves on Occupational Injuries in the Agricultural Sector in Italy. *International journal of environmental research and public health*, 20(4), 2781. <https://www.mdpi.com/1660-4601/20/4/2781>
- Franklin, R. C., Mason, H. M., King, J. C., Peden, A. E., Nairn, J., Miller, L., Watt, K., & FitzGerald, G. (2023). Heatwaves and mortality in Queensland 2010–2019: implications for a homogenous state-wide approach. *International Journal of Biometeorology*, 67(3), 503-515. <https://doi.org/10.1007/s00484-023-02430-6>
- Gaoua, N. (2010). Cognitive function in hot environments: a question of methodology. *Scandinavian Journal of Medicine & Science in Sports*, 20(s3), 60-70. <https://doi.org/10.1111/j.1600-0838.2010.01210.x>
- Grootemaat, P. (2024). Heat waves can be deadly for older adults: An aging global population and rising temperatures mean millions are at risk. <https://theconversation.com/heat-waves-can-be-deadly-for-older-adults-an-aging-global-population-and-rising-temperatures-mean-millions-are-at-risk-230486>
- IPCC. (2022). Annex II: Glossary. In H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, & B. Rama (Eds.), *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 2897-2930). Cambridge University Press. <https://www.ipcc.ch/report/ar6/wg2/chapter/annex-ii/>
- Kenny, G. P., Yardley, J., Brown, C., Sigal, R. J., & Jay, O. (2010). Heat stress in older individuals and patients with common chronic diseases. *Cmaj*, 182(10), 1053-1060. <https://doi.org/10.1503/cmaj.081050>
- Kovats, R. S., & Hajat, S. (2008). Heat stress and public health: a critical review. *Annual Review of Public Health*, 29, 41-55. <https://doi.org/10.1146/annurev.publhealth.29.020907.090843>
- Mason, H., C King, J., E Peden, A., & C Franklin, R. (2022). Systematic review of the impact of heatwaves on health service demand in Australia. *BMC Health Services Research*, 22(1), 960. <https://doi.org/10.1186/s12913-022-08341-3>
- Otte im Kampe, E., Kovats, S., & Hajat, S. (2016). Impact of high ambient temperature on unintentional injuries in high-income countries: a narrative systematic literature review. *BMJ open*, 6(2), e010399. <https://doi.org/10.1136/bmjopen-2015-010399>

Robine, J. M., Cheung, S. L., Le Roy, S., Van Oyen, H., Griffiths, C., Michel, J. P., & Herrmann, F. R. (2008). Death toll exceeded 70,000 in Europe during the summer of 2003. *C R Biol*, 331(2), 171-178.

<https://doi.org/10.1016/j.crvi.2007.12.001>

Shaposhnikov, D., Revich, B., Bellander, T., Bedada, G. B., Bottai, M., Kharkova, T., Kvasha, E., Lezina, E., Lind, T., Semutnikova, E., & Pershagen, G. (2014). Mortality related to air pollution with the moscow heat wave and wildfire of 2010. *EPIDEMIOLOGY*, 25(3), 359-364. <https://doi.org/10.1097/ede.0000000000000090>

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., Moher, D., Peters, M. D. J., Horsley, T., Weeks, L., Hempel, S., Akl, E. A., Chang, C., McGowan, J., Stewart, L., Hartling, L., Aldcroft, A., Wilson, M. G., Garritty, C., . . . Straus, S. E. (2018). PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med*, 169(7), 467-473. <https://doi.org/10.7326/m18-0850>

Varghese, B. M., Hansen, A., Bi, P., & Pisaniello, D. (2018). Are workers at risk of occupational injuries due to heat exposure? A comprehensive literature review. *Safety Science*, 110, 380-392.

<https://doi.org/https://doi.org/10.1016/j.ssci.2018.04.027>

White, R. H., Anderson, S., Booth, J. F., Braich, G., Draeger, C., Fei, C., Harley, C. D. G., Henderson, S. B., Jakob, M., Lau, C. A., Mareshet Admasu, L., Narinesingh, V., Rodell, C., Roocroft, E., Weinberger, K. R., & West, G. (2023). The unprecedented Pacific Northwest heatwave of June 2021. *Nat Commun*, 14(1), 727.

<https://doi.org/10.1038/s41467-023-36289-3>

World Health Organization. (2021). *Falls*. <https://www.who.int/news-room/fact-sheets/detail/falls>

Xiang, J., Bi, P., Pisaniello, D., Hansen, A., & Sullivan, T. (2014). Association between high temperature and work-related injuries in Adelaide, South Australia, 2001-2010. *OCCUPATIONAL AND ENVIRONMENTAL MEDICINE*, 71(4), 246. <https://doi.org/10.1136/oemed-2013-101584>