Are flood early warning systems effective for mitigating the health impacts of flooding: An agile scope of the literature.

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Introduction

An increase in flooding is one of the most important challenges facing the UK as a result of climate change (UK Health Security Agency, 2023; Natural Resources Wales, 2022). Approximately 6.1 million people in the UK currently live in flood prone areas, with 1 in 8 properties in Wales at risk of flooding (UK Health Security Agency, 2023; Natural Resources Wales, 2022). The frequency and magnitude of flood events in the UK is projected to increase, causing harmful impacts to health (UK Health Security Agency, 2023).

Flooding can cause a range of short and long term health problems. In the short term, this includes things such as physical injury or increased risk of developing infection from contaminated flood water. Longer term effects may include things such as respiratory problems from exposure to mold or damp (UK Health Security Agency, 2024). People who experience flooding are also more likely to experience adverse impacts to long term mental health and wellbeing, and are at higher risk of developing depression, anxiety, and post-traumatic stress disorder (UK Health Security Agency, 2023).

Flood early warning systems are one of a number of commonly used protection measures against flooding (UK Health Security Agency, 2023). Flood early warning systems communicate information about forecasted floods to those who may be at risk. In Wales, the flood warning service is managed by Natural Resources Wales, who monitor rainfall, river levels and sea conditions to forecast the risk of flooding. Three tiers of warning can be issued in Wales;

1) flood alerts (for when the risk of flooding is lower but still possible)
2) flood warnings (for when immediate action is required) and
3) severe flood warnings (for danger to life).

Warnings are communicated to people at risk via various means such as telephone call, text message or email. People can also check for flood warnings online or via telephone (Natural Resources Wales, 2023a; 2023b).

The Evidence Service at Public Health Wales were asked to undertake some work summarising the evidence around climate change, flooding, and health, in order to shape Public Health Wales' future climate change research agenda. This agile scope aims to explore one aspect of this topic, by addressing the question: **Are flood early warning systems effective for mitigating the health impacts of flooding, and are there any adverse consequences of flood early warning systems?** A second question around the effectiveness of psychosocial interventions supporting people's mental health and wellbeing in areas at risk of flooding or after a flood has occurred has also been addressed in a separate paper (Hookway A, et al., 2024)

A scoping search of the literature was undertaken in preparation for this work utilising the Public Health Wales Evidence Service's list of reliable secondary evidence sources.[1] No systematic review that directly addressed the research question was identified, and therefore a decision was made to focus on identifying all available evidence (regardless of methodology) on the effectiveness of early warning systems for mitigating the health impacts of flooding, using an agile scope approach (as outlined in Appendix A). It should be noted however that it is possible that not all evidence relating to this topic was identified, as searches were not exhaustive. Included studies were critically appraised using appropriate checklists and comments on methodological rigour have been included in the data extraction tables (appendix C) and considered in the narrative summary of findings.

Methodological considerations and limitations:

Agile scoping reviews utilise rapid methodology to provide a broad overview of the evidence base on a topic of interest. They are intended to guide and inform further work rather than to be used for policy and practice. The findings and conclusions included are those of the source authors and not an interpretation by the Evidence Service. Factors relevant to answering the above question identified from the studies have been extracted and briefly summarised within this report. If a specific factor is of interest, it is advisable to read the sources from where they were taken in more detail. If utilising any research included in this scope to inform policy, it is important to consider the methodological quality and generalisability of the findings to your context.

Objectives

This agile scoping review aims to answer the following question:

1) Are flood early warning systems effective for mitigating the health impacts of flooding, and are there any adverse consequences of flood early warning systems?

[1] Sources of guidelines and secondary level evidence that have been produced using a robust methodology (which adheres to systematic review principles and includes critical appraisal using a recognised tool). The list of resources can be found in appendix B.

Key Messages

- Very little research has been identified which explores how effective flood early warning systems are for mitigating the health impacts of flooding, suggesting a gap in the evidence base.
- Most research on flood early warning systems looks at the systems effect on tangible losses from flooding (i.e., damage to property), with very little exploring the effectiveness of flood early warning systems for reducing the negative health effects of flooding.
- One cross-sectional study was identified which found no significant differences in short or long term health effects between those who received a flood warning and those who did not receive a flood warning (DEFRA, 2004).
- However, analysis from the same cross-sectional study suggests that for those who did receive a flood early warning, the greater the amount of time from warning to flood, the lesser the negative short or long term health effects from flooding (DEFRA, 2004).
- One further cross-sectional study found that depression and post-traumatic stress disorder were higher amongst people who were displaced from flooding and reported receiving no flood warning, compared to those who received a flood warning more than twelve hours in advance of a flood event. However, there were no differences in anxiety scores between these two groups (Munro A, et al., 2017).
- Modelling from Switzerland suggests that a highly efficient early warning system in the Sihl valley has the potential to avoid approximately 75% of fatalities, 25% of non-fatal injuries and 18% of post-traumatic stress disorders in the case of a major flood event (Balbi S, et al., 2014; Balbi S, et al., 2016)
- No studies were identified which directly identified or examined adverse effects of flood early warning systems on people's health. However, research from focus group discussions after flooding in England and Wales identified that older people, those who lived alone, the disabled and parents of young children commonly found automated voice messaging service flood warnings frightening (DEFRA, 2005).
- False alarms were also identified by focus groups as causing some anxiety, however in most cases people said they would rather have false alarms than no warning at all (DEFRA, 2005).
- Further modelling or evaluation of flood early warning systems to explore their effectiveness for mitigating both short and long term physical and psychological health effects of flooding, and exploring adverse effects may help to fill the gap in the evidence base.
- Warnings can also only help mitigate the health impacts of flooding if people respond appropriately to them. Although outside of the scope of this piece of work, examining people's perceptions, acceptance and responses to early

warnings may also provide insight into how to maximise the effectiveness of such systems and subsequently reduce negative health impacts from flooding.

Findings

A limited number of relevant studies were identified from our search of the literature, suggesting that little research has been published exploring flood early warning systems effectiveness for mitigating the health impacts of flooding.

No systematic reviews directly addressing the question were identified from the initial search of reliable secondary evidence sources. Therefore, a decision was made to focus on identifying all available evidence meeting our inclusion criteria (regardless of methodology), and our search was expanded to reflect this (please refer to Appendix B for a list of resources searched).

Subsequently, seven studies (across eight publications) were identified for inclusion in this agile scoping review; one qualitative systematic review (Yari A, et al., 2020), one case crossover study (Stanley C, et al., 2023), one modelling study (Balbi S, et al., 2014; Balbi S, et al., 2016), one non-systematic literature review (Parker D, et al., 2005), one qualitative study (DEFRA, 2005), and two cross sectional studies (DEFRA, 2004; Munro A, et al., 2017). The research was published between 2004 and 2023. Included studies looked at a limited range of health outcomes. Two focused broadly on physical and psychological health effects (DEFRA, 2004; Parker D, et al., 2005), one on just psychological health effects (Munro A, et al., 2017), one focused on death, physical injury, and post-traumatic stress disorder (Balbi S, et al., 2014; Balbi S, et al., 2016), one solely on death from flooding (Yari A, et al., 2020), one on hip fractures (Stanley C, et al., 2023), and one on vulnerability, including some psychological impacts (DEFRA, 2005). A detailed data extraction table of these sources can be found in Appendix C.

The qualitative systematic review (Yari A, et al., 2020) aimed to investigate and categorize the underlying risk factors for flood death and included 48 studies, with the majority from the USA (n=12), the Netherlands (n=8), Australia (n=6), Greece (n=5), England (n=4) and France (n=4). The authors conducted a thematic synthesis and coded one hundred and fourteen risk factors for flooding. These were grouped into five categories that could have an influence on flood deaths; hazard related, individual, environmental, socioeconomic, and managerial factors. **Lack of early warning system and warning time was identified as one risk factor for death from a flood in the thematic synthesis, under the managerial category.** The review did not look at any further health effects from flooding, beyond death from a flood. It

should also be noted that the quality of the review was poor, as the authors did not report the reviews inclusion/exclusion criteria clearly, and no quality assessment of the included studies was undertaken. This limits our confidence in the findings as we cannot make an assessment on the risk of bias from the included studies or assess generalisability. Therefore, results should be interpreted with caution.

A literature review by Parker D, et al. (2005) discussed what is known about the socioeconomic benefits of flood forecasting, warning, and response systems. This paper is a non-systematic narrative review and therefore is inherently subject to various types of bias such as selection bias. The conclusions should therefore be interpreted with caution. The paper suggested that reducing the adverse impacts of flooding depends on three elements; the nature of the flood event, the development and effectiveness of flood early warning systems, and the characteristics of the flood affected population and their response (Parker D, et al., 2005). Although the development and effectiveness of flood early warning systems have been the subject of research and evaluation, much of this research focuses on how flood warning systems can mitigate 'tangible direct losses' of flooding such as economic impacts from damage to buildings/ infrastructure (Parker D, et al., 2005). In contrast, early warning systems effectiveness for mitigating intangible losses from flooding (such as loss of life, physical injury, ill health, and psychological impacts) have not been subject to the same level of research (Parker D, et al., 2005). Although the literature review was published in 2005, our agile scoping search did not identify a great deal of more recently published research on the effect of early warning systems for mitigating intangible losses from flooding, suggesting that this conclusion is still relevant today.

The above literature review (Parker D, et al., 2005) additionally summarised a cross-sectional research study carried out in 2001/02 by the UK Government's Department for Environment, Food and Rural Affairs (DEFRA) and the Environment Agency, which met the inclusion criteria for this agile scope. The research undertaken by DEFRA (2004) intended to develop a robust methodology that could be used to assess the impacts of flood alleviation measures on human health and wellbeing. Surveys and focus groups were used during the pilot phase to develop a questionnaire to assess the health impacts of flooding and the willingness of people to pay to avoid such impacts. This questionnaire was subsequently refined, and 1,510 face to face interviews were conducted in 30 locations across England in Wales which had previously been subject to flooding as part of the main research.

The research looked at the effects of flooding on health more broadly and found that flooding causes both short-term physical effects (such as increased susceptibility to certain illnesses) and short and long-term psychological effects (such as increased stress or anxiety), when measured using the General Health Questionnaire 12-item version (GHQ-12) and the Post-Traumatic Stress Syndrome

(PTSS) validated scales, or a self-reported health checklist (DEFRA, 2004). Further analysis was undertaken to explore factors that may influence these measures of health, including sociodemographic factors, flood characteristics and post-flood factors.

Statistical analysis revealed mixed results for the effect of early warnings. **Bivariate statistical analysis revealed that the receipt of a warning and warning lead time had little or no effect upon the short or long-term health effects people experience from flooding.** No significant differences in PTSS intensity or current GHQ-12 scores were found between those who had received a warning and those who had not received a warning, for either short term or long term health effects (DEFRA, 2004).

However, further analysis revealed that **for those who did receive a warning, there were statistically significant correlations between the length of warning time and health effect scores, suggesting that the greater the warning time, the lesser the consequent negative health effects of flooding** (DEFRA, 2004).

This was similarly found in multivariate statistical analysis, which revealed a significant ($p<0.05$) relationship between warning time and levels of stress over the long term (measured using PTSS scores) and between warning time and general health at the time of flooding (measured using GHQ-12 scores). This further suggests that **increased warning time reduced both health effects at the time of flooding and stress over the long term** (DEFRA, 2004). No major quality concerns were identified when appraising this cross-sectional study, and although some health effects were measured using self-reported scales, analysis of the association between flood warning, warning lead time and subsequent health effects was undertaken using health scores from validated scales.

One further cross-sectional study which took place in England was also identified, which aimed to examine the effects of evacuation and displacement due to floods on depression, anxiety, and post-traumatic stress disorder indicators (Munro A, et al., 2017). The authors conducted surveys of people in flood- affected postcodes in five English counties one year after a flooding event (winter 2013/4). Data from 622 respondents were used in the analysis. Although flood early warning systems were not the main focus of the study, **the authors found that depression and post-traumatic stress disorder were higher amongst people who were displaced and reported receiving no flood warning compared to those who have received a flood warning more than twelve hours in advance of a flood event ($p=0{\cdot}04$ for depression, $p=0{\cdot}01$ for post-traumatic stress disorder). There was no significant difference in anxiety scores.** The study was found to be of good methodological quality.

One modelling study (Balbi S, et al., 2014; Balbi S, et al., 2016) was identified that met our inclusion criteria. The researchers used a spatially explicit Bayesian network

model to estimate the benefits of improving an existing flood early warning system that covered the lower part of the Sihl valley in Switzerland (including the city of Zurich). The model compared the current early warning system (baseline) with one of maximum theoretical effectiveness (in terms of reach/scope, reliability and lead time). The modelling results indicated that the potential benefits of an improved early warning system could be particularly high in the case of a major flood event, avoiding approximately 75% of fatalities, 25% of non-fatal physical injuries and 18% of post-traumatic stress disorders. Although the authors explain and justify the rationale for using this particular type of Bayesian network model, the model limitations have not been adequately discussed. It is also unclear from the paper whether the model has been sufficiently validated, and so results should be treated with caution.

Although not directly relevant, one case-crossover study was identified from the Republic of Ireland which aimed to examine the relationship between hip fractures amongst older people and weather warnings (Stanley C, et al. 2023). The authors hypothesised that higher rates of hip fractures occur during weather warnings and undertook a retrospective review and statistical analysis of 7 years' worth of data on weather warnings and hospital admissions for hip fractures. As part of this analysis, they undertook a comparison of weather warnings by element, and found that there were more hip fractures during weather warnings with a flooding element, than when there were no weather warnings in place, however the association was not statistically significant when analysed using either a panel analysis (incident rate ratio: 1.22, 95% CI: 0.76 to 1.94, $p < 0.414$), or case crossover analysis (incident rate ratio: 1.14, 95% CI: 0.67 to 1.92, $p < 0.635$). It should be noted that the paper analysed weather warnings more broadly, and it is unclear whether the warnings with a flooding element are delivered by a 'flood early warning system' that meets our definition (as set out in table 1 p.12 of this report), or if these were more general weather warnings. Furthermore, whilst the authors found an increase in hip fractures following weather warnings with a flooding element, the study did not ascertain why this occurred (for example, as a direct result of the weather, or for other reasons). The authors suggested it could have been a result of older people left vulnerable in their homes as carers were instructed not to travel as a result of the weather warnings, but this was not analysed further.

No studies were found which directly identified or examined adverse effects of flood early warning systems on people's health. However, one qualitative study by DEFRA and the Environment Agency was identified which included some insights into potential effects (DEFRA, 2005). The study explored people's vulnerability to flooding by conducting focus group discussions across six areas of England and Wales in which severe flooding had occurred in autumn 2000. The results were then thematically synthesised. Participants in focus groups suggested that older residents were particularly badly affected by fear and anxiety from flood warnings, with some

reportedly confused about their meaning. Some participants who received an automated voice messaging service (AVM) found this frightening, with feelings of horror common particularly amongst older people, those who lived alone, the disabled and parents of young children.

False AVM alarms were also identified by focus group participants as causing some anxiety, however in most cases people said they would rather have false alarms than no warning at all. This qualitative study includes the perspectives of a varied range of participants, albeit with a limited number of quotes provided in the report. However, there is no mention of any philosophical theory or standpoint underpinning the research, and the authors do not provide a description of the method of data analysis used nor a reflection on any type of bias which may have been introduced into the study. This makes it difficult to provide an overall assessment of the quality and validity of the findings.

Discussion and limitations

This agile scope does include some limitations which should be taken into account when considering the lack of identified evidence on this topic. Firstly, although the effectiveness of flood early warning systems for reducing tangible losses from flooding (such as damage to buildings/infrastructure) is well researched, it is difficult to quantify the level of effectiveness that early warning systems have on mitigating the health effects of flooding. Evaluating the effect that early warning systems have with regards to reducing the health impacts of flooding may be difficult in isolation, as flood warning systems are just one element of flood risk management. Modelling studies could however provide some insight.

Secondly, flood early warning systems differ greatly, in terms of their setup, reach, scope and delivery methods. These differences may have mitigating effects themselves on the effectiveness of the early warning system, however this was not sufficiently explored in the limited research evidence we identified. Similarly, warnings can only help people avoid flood impacts if people know how to respond effectively to them (Thieken A, et al. 2021), therefore people's knowledge and behaviour upon receiving a warning may also have a mitigating effect on the effectiveness of an early warning system for reducing the health effects of flooding. We did not identify a large body of research which directly evaluates the effectiveness of early warning systems for reducing negative health effects. However, there is likely to be a body of research in the literature which examines and evaluates peoples' perceptions of, and responses to flood warnings. This type of research may add to the findings from this agile scope by providing useful insights

into how to maximise the effectiveness of such systems and subsequently reduce negative health impacts from flooding.

Thirdly, although our search was expanded from just focusing on secondary literature to also include primary studies, our inclusion criteria remained focused, to allow us to identify evidence that might be broadly more relevant to Wales. This included limiting our inclusion to studies conducted in OECD countries, and to those explicitly examining flood early warning systems, rather than other types of disaster early warning systems. It is possible that further research may exist from non-OECD countries on the effectiveness of flood early warning systems for reducing the negative health effects of flooding, however whether these findings could then be generalised to Wales would need to be thoroughly examined. Generalisability should also be considered when exploring the evidence we have identified from OECD countries other than the UK, as geographical and climate patterns across these countries may vary compared to those in Wales.

Similarly, early warning systems exist for other types of natural disasters that occur across the world and the impact of these on mitigating subsequent health effects may have been evaluated, however they are similarly likely to be less generalisable to Wales. Finally, although we searched multiple databases and websites for both published and grey literature, it is possible that further reports may exist within the grey literature that our searches have not picked up.

Conclusion

In conclusion, this agile scope has identified very little research that examines the effectiveness of flood early warning systems for mitigating the health impacts of flooding, or whether there are any adverse consequences of flood early warning systems on health. Much of what has been identified also includes methodological flaws and should therefore be interpreted with caution. Literature suggests that most evaluations of flood early warning systems appear to look at how they can mitigate the tangible direct losses from flooding to things such as property and infrastructure, with very little focus on how effective they are at reducing the negative health effects of flooding (Parker D, et al., 2005). Although some modelling studies have been conducted, they remain limited in their scope and generalisability. Further modelling or evaluation of flood early warning systems to explore their effectiveness for mitigating both short and long term physical and psychological health effects of flooding would help to fill this gap in the evidence base.

Options for further evidence review work

- Flood early warning systems can only help to mitigate the health impacts of flooding if people respond appropriately to them. Further evidence review work could be undertaken to explore people's perceptions, acceptance, and responses to early warning systems. This could help to provide insight into how to maximise the effectiveness of such systems and subsequently help to reduce negative health impacts that might be experienced from flooding.

Methods

Appendix A (technical appendix) provides an outline of the general rationale and methods used to develop agile scopes. The following methodology outlines the approach undertaken for this agile scoping report.

This agile scope was initially limited to only include reviews produced using explicit and reproducible methods of systematic searching, critical appraisal of quality and synthesis of the primary literature on the topic. This is an acceptable way to rapidly assess the majority of the evidence base, and although it does not intend to identify every publication on a topic, it would allow for the production of an overview. However, the initial search of the literature did not identify much secondary evidence addressing the topic and so a decision was made to focus on identifying all available evidence on flood early warning systems and their effectiveness for mitigating the health effects of flooding.

Data sources: Fifteen reliable evidence sources were searched that adhere to robust systematic review principles[2], along with Medline, Scopus, Epistemonikos and google scholar, were searched for published evidence using search terms and strategies designed specifically for each data source. Searches were conducted using a combination of the following terms:

- Flood(s), flooding
- Warning(s), forecast(s), alert(s), risk(s), control(s), system(s), management, monitoring
- Health, mental health, physical health, psychological health, anxiety, fear, worry

An additional five sources were also searched for grey literature (details in appendix B). A full search strategy for Medline along with a full list of resources searched is included in appendix B (search appendix).

Study selection: All search results were assessed for inclusion. Two reviewers independently screened the reviews for relevance at title, abstract and full-text level against the inclusion criteria outlined in table 1.

Data extraction: Where possible, data reporting relevant characteristics were extracted from the included studies into a data extraction table (table 2, appendix C).

[2] Follows core systematic review principles: comprehensive and stated search strategy, selection of sources based on objective criteria, assessment of risk of bias of primary sources and/or is a methodology developed by an expert body e.g., NICE. For a full list of sources searched, please refer to Sources searched section of the report.

A second reviewer checked the extracted data. Disagreements at any stage were resolved through discussion with a third reviewer.

Quality assessment: The included studies were critically appraised for their quality using various study specific checklists. Details of the checklist used and the methodological rigour of the studies are included in the data extraction tables in Appendix C.

Table 1: Inclusion criteria

Review question 1:		
Are flood early warning systems effective for mitigating the health impacts of flooding, and are there any adverse consequences of flood early warning systems?		
	Include:	Exclude:
Participants	People at risk of flooding or have experienced flooding.	
Intervention / exposure	Flood early warning systems.	
Comparison	Alternative intervention, no intervention or no comparison group	
Outcomes	All health outcomes (including adverse effects/consequences)	Non health related outcomes
Other Study Considerations		
Any study design. OCED countries (comparable to UK)		

References

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DEFRA/Environment Agency. (2004). *The Appraisal of Human-Related Intangible Aspects of Flooding*. DEFRA/Environment Agency flood and costal defence R&D programme: technical report FD2005/TR. London: DEFRA.

Hookway A, et al., (2024). *What interventions are effective to support people's mental health and wellbeing (a) in areas at risk of flooding; and (b) after a flood has occurred: An agile scope of the literature.* Cardiff: Public Health Wales.

Munro, A, et al., (2017). Effect of evacuation and displacement on the association between flooding and mental health outcomes: a cross-sectional analysis of UK survey data. *Lancet Planet Health,* 1:e134-41.

Natural Resources Wales, (2023a). *How we forecast floods, issue warnings and assess flood risk*. https://naturalresources.wales/flooding/managing-flood-risk/how-we-forecast-floods-issue-warnings-and-assess-flood-risk/?lang=en (last accessed: 03/04/2024)

Natural Resources Wales, (2023b). *Sign up to receive flood warnings.* https://naturalresources.wales/flooding/sign-up-to-receive-flood-warnings/?lang=en#:~:text=Flood%20alerts%20cover%20large%20areas,more%20often%20that%20flood%20warnings. (last accessed: 03/04/2024).

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Parker D., et al. (2005). Socio-Economic benefits of flood forecasting and warning. *International conference on innovation advances and implementation of flood forecasting technology,* Tromsø, Norway

Stanley C, et al. (2023). The association between weather warnings and hip fractures in the Republic of Ireland. *Archives of Osteoporosis.* 18:53. Doi: 10.1007/s11657-023-01243-9

Thieken A, et al. (2023). Performance of the flood warning system in Germany in July 2021 – insights from affected residents. *Natural hazards earth system sciences.* 23, 973-990.

UK Health Security Agency, (2024). *Flooding and health: advice for the public.* UK Government. https://www.gov.uk/government/publications/flooding-and-health-public-advice/flooding-and-health-advice-for-the-public#:~:text=Flooding%20can%20cause%20a%20range,exposure%20to%20mould%20and%20damp. (Last accessed: 02/04/2024)

UK Health Security Agency, (2023). *Health Effects of Climate Change (HECC) in the UK: 2023 report. Chapter 3. Climate change, flooding, coastal change, and public health.* London: UKHSA. https://assets.publishing.service.gov.uk/media/657086ad746930000d488919/HECC-report-2023-chapter-3-flooding.pdf (last accessed: 02/04/2024).

Yari A, et al. (2020). Risk factors of death from flood: findings of a systematic review. *Journal of Environmental Health Science and Engineering.* 18: 1643-1653. Doi: 10.1007/s40201-020-00511-x

Appendix A: Technical document

AGILE SCOPES are stakeholder-driven, rapid, systematic overviews of the evidence on a topic. They provide a transparent and reliable overview of the evidence landscape and are useful to:

- establish what literature exists
- help to refine a broad question
- identify gaps in the evidence
- inform further work by stakeholders.

The scopes employ a process of *up to* three steps, depending on what evidence is available for the topic. Progress from one step to another is discussed and agreed with stakeholders.

1. The first step is to draw on existing systematic review evidence identified from trusted sources[3] (secondary evidence sources that use robust methodologies) where this exists. The Evidence Service does not undertake critical appraisal of these reviews. A brief report outlining evidence identified is produced.
2. If little or no evidence has been identified at this stage, a very simple search will be conducted in Medline using key words only to establish the benefit of conducting further searches in a broader range of databases. A summary of the search results (i.e., number, study design, relevancy etc.) will be provided in the agile scope to help inform stakeholders.
3. Where little or no trusted secondary evidence exists, and if identified as potentially beneficial from the Medline search conducted in step 2, the scope may be extended, at the request of the stakeholder to include a search for systematic reviews or primary literature in Google Scholar, Scopus or Medline, as appropriate. At this and any subsequent step, quality assessment of the identified evidence would be required.
4. Primary studies are not usually included, unless few or no systematic reviews are identified in the preliminary phase of step 1, or stakeholders request it following earlier work they have undertaken.

Considerations

- The scope does not attempt to identify all evidence on a given topic.

[3] The sources on the Evidence Service list of trusted secondary evidence resources are provided in Table 1

- Not all outcomes identified in the literature will necessarily be included in this scoping report for a number of reasons, including:
    - Outcomes included in the scope are limited to those that are relevant to the stakeholders' original question.
    - Outcomes may not have been reported in the secondary sources, although it may exist in the primary literature. These outcomes will therefore not be included within the scoping report.
- Findings within included reviews are not assessed for generalisability to the Welsh context. [*It would be a complex process as secondary evidence is likely to include studies from multiple countries.*] This would need to be considered by stakeholders if using secondary evidence to inform policy and practice. Additional work could be requested if necessary.
- The scope summarises the findings and conclusions of the source authors. If a specific element of the report is of particular interest, it is advisable to read the source(s) from which it originates in more detail, as this will provide more context. Further work may be undertaken on specific areas if required.
- Hyperlinks to the included evidence are provided in the data summary table. In many instances, that evidence is freely available. If not, your Trust's Knowledge and Library service can help. NHS Wales Library Service | NHSWLS

Methods

All agile scopes follow a broad methodology and structure, with only small variations according to the question and evidence base identified. Through discussions with stakeholders, a research question and inclusion/exclusion criteria are developed using the PICO/PECO format (population, intervention/exposure, comparator, outcome). **Note: stakeholders are requested to indicate evidence/information they have already identified.**

As noted above, the methodology utilised is designed to provide rapid information to stakeholders. In the first step, restricting the search to sources from the trusted secondary evidence resources list reduces the time taken both in terms of search scope and by excluding the need for critical appraisal.

The search strategy developed is based on the inclusion criteria and uses key words. The scope is restricted to including only English language evidence and publication date limits may be imposed when the search results are too large to manage in a short timeframe, or where the stakeholder requires work to be completed within a specific timeframe. Additionally, the countries included may be limited, particularly where generalisability to a Welsh context is a particular concern.

All search results and screening for relevant systematic reviews are maintained in an EndNote library or suitable reference management system. Inclusion at title and

abstract are calibrated by two reviewers independently screening the first 10% to 20% of systematic reviews for relevance, with the remainder being screened by a single reviewer. Full text screening decisions are made by two reviewers. Data on study characteristics and findings relevant to the question are extracted by one reviewer and checked by a second. The evidence is them summarised narratively to answer stakeholder questions. Evidence gaps within the secondary literature are reported.

If none, or limited evidence is identified from the trusted secondary sources list, a brief search is conducted in Medline using basic key word searches to establish the benefit of conducting further searches in a broader range of databases. A summary of the search results (i.e., number, study design, relevancy etc.) will be provided in the agile scope.

Findings

The agile scoping report contains a narrative summary and a data table. The narrative summary is a broad overview of the evidence identified, with a particular focus on elements highlighted as important by stakeholders. Data tables include the reference (with a hyperlink), information on study characteristics and findings. The information in the data tables will vary according to the question, types of included studies and requirements of stakeholders. The table also includes a comment section highlighting any elements of particular interest to stakeholders along with any limitations that should be considered.

The report concludes with an 'options for further work' section. These suggestions are based on the evidence identified and provide an explicit rationale where further evidence review work is recommended. This information will be informed by the additional brief search conducted in Medline to help assess how much additional information, and the likely benefits of conducting additional work are. These findings will be provided to stakeholders to ensure they can make an informed decision on what to do next.

Appendix B: Search Appendix

Resources to be searched in step 1 of methodology:	
Cochrane database of systematic reviews - https://www.cochranelibrary.com/cdsr/reviews	Date of search: 14/02/2024
NICE – https://www.nice.org.uk/guidance	Date of search: 14/02/2024
Joanna Briggs Institute -	Date of search: 14/02/2024
Prospero – https://www.crd.york.ac.uk/prospero/	Date of search: 14/02/2024
National Institute for Health Research (NIHR) Public Health Research – https://www.journalslibrary.nihr.ac.uk/phr/about-the-phr-journal.htm	Date of search: 14/02/2024
The Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre) – http://eppi.ioe.ac.uk/cms/	Date of search: 14/02/2024
What Works Centre for Wellbeing – https://whatworkswellbeing.org/about-us/	Date of search: 15/02/2024
What Works Centre for Local Economic Growth – https://whatworksgrowth.org/about-us/	Date of search: 15/02/2024
Health Technology Wales – https://healthtechnology.wales/	Date of search: 15/02/2024
Health Technology Assessments (Ireland) – https://www.hiqa.ie/areas-we-work/health-technology-assessment	Date of search: 15/02/2024
National Institute for Health Research Health (NIHR) Technology Assessment (HTA) Journal – https://www.journalslibrary.nihr.ac.uk/hta/about-the-hta-journal.htm	Date of search: 15/02/2024
Agency for Healthcare Research and Quality (AHRQ)	Date of search: 15/02/2024
Canadian Agency for Drugs and Technologies (CADTH) – https://www.cadth.ca/evidence-bundles-view	Date of search: 15/02/2024
Evidence Synthesis Program Reports (va.gov) – https://www.hsrd.research.va.gov/publications/esp/reports.cfm	Date of search:

	15/02/2024
Scottish Intercollegiate Guidelines Network (SIGN) clinical guidelines – https://www.sign.ac.uk/our-guidelines/	Date of search: 15/02/2024
Additional resources to be searched in steps 2-3 of methodology:	
Google Scholar – https://scholar.google.com/	Date of searches: 15/02/2024 19/02/2024 26/02/2024 04/03/2024
Epistemonikos - https://www.epistemonikos.org/	Date of searches: 19/02/2024 26/02/2024
Scopus - https://www.scopus.com/search/form.uri?zone=TopNavBar&origin=searchbasic&display=basic#basic	Date of search: 23/02/2024
Medline – https://www.scopus.com/search/form.uri?display=basic#basic	Date of search: 26/02/2024

Additional Sources searched for grey literature	
The European Environment Agency	Date of search: 20/02/24
CEE Database of Evidence Reviews (CEEDER) – Environmental Evidence	Date of search: 20/02/24
GreenFile https://www.ebsco.com/products/research-databases/greenfile	Date of search: 20/02/24
IFRC Psychosocial Centre PS Centre	Date of search: 20/02/24
Climate ADAPT Home — Climate-ADAPT (europa.eu)	Date of search: 20/02/24

Medline final search string:

Ovid MEDLINE(R) Epub Ahead of Print and In-Process, In-Data-Review & Other Non-Indexed Citations <February 23, 2024>

1 flood*.ti,ab. or floods/ 24317

2 (warning* or forecast* or alert* or risk* or control* or system* or "management" or "monitoring").ti,ab. 11638693

3 1 and 2 13328

4 ("mental health" adj3 (impact* or effect* or outcome*)).ti,ab.22296

5 (health adj3 (impact* or effect* or outcome*)).ti,ab. 255823

6 (physical adj3 (impact* or effect* or outcome*)).ti,ab. 43774

7 (psychological adj3 (impact* or effect* or outcome*)).ti,ab. 30651

8 (psychosocial adj3 (impact* or effect* or outcome*)).ti,ab. 15245

9 (anxiety or fear or worry).ti,ab. 349170

10 4 or 5 or 6 or 7 or 8 or 9 657048

11 3 and 10 620

12 limit 11 to english language 595

Appendix C: Data extraction

Table 2: Data extraction of the reviews identified in the scoping search (in alphabetical order)			
Reference	Aim/Question	Abstract or summary	Comments
Balbi S., et al. (2014). Estimating the benefits of early warning systems in reducing urban flood risk to people: a spatially explicit Bayesian model. *2014 Proceedings of the 7th Intl. Congress on Env. Modelling and Software*, San Diego, USA.	To present a methodology to assess flood risk to people, which integrates people's vulnerability and ability to cushion hazards by coping and adapting.	**Study design:** Modelling study **Location:** The study area covers the lower part of the Sihl valley (Switzerland) including the city of Zurich. **Method:** Flood risk to people is modelled using a spatially explicit Bayesian network model calibrated on expert opinions. The model is used to estimate the benefits of improving an existing Early Warning System, taking into account the reliability, lead-time and scope (i.e., coverage of people reached by the warning). **Result:** Results indicate the importance of early warning systems in reducing the risk to human life. An extremely effective early warning system can avoid approximately 75% of fatalities with respect to the baseline both in the case of flood event during the day and overnight. The effect on injuries and post-traumatic stress disorder is lower, around 20%. **Conclusion:** This study demonstrates that scenario analysis focused on the potential benefits of early warning system improvement and preparedness in flood risk management is possible by means of methodologies that employ quantitative data (flood modelling and GIS data), and semi-quantitative information integrating subjective (expert opinions) and local knowledge (risk perception and early warning system baseline). In particular, the application of BNs allows us to	**Generalisability:** Modelling study area is Sihl valley Switzerland, this covers urban & rural area but topography/ geography likely to be different to Wales. Generalisability would need to be explored further. **Methodological rigour:** Critically appraised using the ISPOR-AMCP-NPC checklist for modelling studies (comments on quality below): Paper is vague and lacks detail on whether the model has been validated sufficiently. Decision/rationale for using this particular type of model has been discussed / justified. However, limitations not really discussed. Process for development has been documented in paper. Non-technical documentation

		produce probabilistic results and include an explicit visualization of model uncertainty. Given our result, policy makers might need to shift their attention from structural defences to a combination of structural and non-structural defence measures.	does not appear to be freely available. Unclear if detailed technical documentation is available although authors do suggest it. Model data is based on expert opinion – unsure of suitability.

Balbi S., et al. (2015). A spatial Bayesian network model to assess the benefits of early warning for urban flood risk to people. *Nat. Hazards Earth Syst. Sci. Discuss.*, 3, 6615–6649. doi:10.5194/nhessd-3-6615-2015	To present a novel methodology to assess flood risk to people by integrating people's vulnerability and ability to cushion hazards through coping and adapting.	**Study design:** Modelling study **Location:** The study area covers the lower part of the Sihl valley (Switzerland) including the city of Zurich. **Method:** Flood risk to people is modelled using a spatially explicit Bayesian network model calibrated on expert opinion. Risk is assessed in terms of: (1) likelihood of non-fatal physical injury; (2) likelihood of post-traumatic stress disorder; (3) likelihood of death. The model is used to estimate the benefits of improving an existing Early Warning System, taking into account the reliability, lead-time and scope (i.e., coverage of people reached by the warning). **Result:** Model results indicate that the potential benefits of an improved early warning in terms of avoided human impacts are particularly relevant in case of a major flood event: about 75% of fatalities, 25% of injuries and 18% of post-traumatic stress disorders could be avoided. **Conclusion:** Early warning systems are recognised as an efficient risk reduction option in flood prone areas, as flood forecasting undergoes technological innovation in terms of reliability and lead time. However, there are still few studies about the quantification of the benefits of early warning systems. In this article we demonstrate a novel approach based on the KULTURisk framework, which attempts to fill this research gap for what concerns the potential avoided consequences to human targets. In general, the benefits of a risk prevention measure are the difference between potential consequences determined under the baseline scenario and the potential consequences under an alternative scenario where new or improved risk prevention measures are put in place. We simulate a scenario analysis focused on the potential benefits of early warning systems improvement. This simulation suggests that the potential benefits of a fully efficient early warning systems in terms of avoided human impacts are particularly relevant in case of a major flood event.	**Generalisability:** Modelling study area is Sihl valley Switzerland, this covers urban & rural area but topography/ geography likely to be different to Wales. Generalisability would need to be explored further. **Methodological rigour:** Critically appraised using the ISPOR-AMCP-NPC checklist for modelling studies (comments on quality below): Paper is vague and lacks detail on whether the model has been validated sufficiently. Decision/rationale for using this particular type of model has been discussed / justified. However, limitations not really discussed. Process for development has been documented in paper. Non-technical documentation does not appear to be freely available. Unclear if detailed technical documentation is available although authors do suggest it. Model data is based on expert opinion – unsure of suitability.

DEFRA/Environment Agency. (2005). *Flood warning for vulnerable groups: a qualitative study* DEFRA/Environment Agency flood and costal defence R&D programme: technical report W5C-018/3. London: DEFRA.	The research aimed to provide a detailed understanding of whether some groups within the population are particularly vulnerable to floods and, if so, to explain why this is the case. It also developed recommendations for improving the content and dissemination of flood warnings for these groups.	**Study design:** Qualitative study **Location:** Six locations across England and Wales **Method:** The qualitative research was conducted in two parts. Phase one examined vulnerability to flood warning and flood event with reference to groups suggested by key informants in six areas within England and Wales where severe flooding had occurred in Autumn 2000. Phase two examined flood warning response and event impact amongst four of those categories identified by key informants as particularly vulnerable. Phase two also addressed the public perceptions of Environment Agency flood advice and warning artefacts and examined perceptions with regard to the underlying causes of flooding in the UK and beyond. Suitable areas for data collection were identified via in-depth interviews with 78 key informants. Six sites were chosen for data collection: five in England and one in Wales (Ruthin, Denbighshire). Focus groups were then conducted in the different areas amongst three groups of older people, three groups of parents of young children, one group of single parents of young children and two groups of 'new' residents. The majority of focus groups contained between six and ten participants, and each group met on two occasions yielding a total of 18 focus group discussions. In-depth interviews were also conducted with ten disabled people. **Result:** The research identified the following that could be interpreted as adverse consequences of flood early warning systems: The analysis of the focus group discussion from Iford Bridge Home Park in Christchurch/Bournemouth; England, reported that *"older residents, defined by one informant as being those over eighty years of age, were said by some to be particularly badly affected by flood warnings. Many were reportedly confused about their meaning and there*	**Generalisability:** **Methodological rigour:** Methodological quality was assessed using the JBI Critical Appraisal Checklist for Qualitative Research (comments on quality below): This research uses focus group discussions and interviews to generate findings for analysis, however there is no detail on the underpinning philosophical perspective they have chosen to underpin the study or a description of the method of data analysis. The paper does not report whether ethical approval for the research was sought. The paper does not include any personal reflection from the authors regarding their potential influence on the research. However, the findings do appear to be organised and displayed logically, with some direct participant quotes given. The conclusions and recommendations of the report do appear to flow from

		was much conflicting advice within the site about what action should be taken." The analysis of the focus group discussion in Bewdley found that "*fear and anxiety on receipt of warnings also rendered some older people at risk* [of vulnerability to flooding]." The focus group analysis also found that some participants found the automated voice messaging service (AVM) warning frightening, with feelings of horror common amongst all categories particularly amongst older people, those who lived alone, the disabled and parents of young children. Some participants described receiving an AVM call as a "shocking experience", which was particularly worrying for people away from home and uncertain on whether or not they needed to take action. False alarms also caused some anxiety, but in most cases people said they would rather have false alarms than no warning at all. Conclusion: The research makes general recommendations for practice and advice arising from the key informant and focus group interviews contained within the report. The principal issues include: improving levels of knowledge, awareness and preparedness with regard to flood and flood warning; communication networks; accountability; local knowledge and the provision of flood warnings.	the overall analysis/ interpretation of the data.

DEFRA/Environment Agency. (2004). *The Appraisal of Human-Related Intangible Aspects of Flooding.* DEFRA/Environment Agency flood and costal defence R&D programme: technical report FD2005/TR. London: DEFRA.	To develop a robust, yet simple-to-use, methodology so that that impacts of human health and wellbeing can be accounted for in assessing the benefits of flood alleviation measures.	**Study design:** Cross sectional survey design (Phase 2) **Location:** England and Wales **Method:** The work was carried out in two parts: Phase 1 - to develop and validate survey instruments (using focus groups and pilot surveys) for i) health impacts; and ii) estimation of WTP (willingness to pay); and Phase 2 - to undertake national health and WTP surveys and, based on the results, develop an economic appraisal methodology. In Phase 2, 1,510 face to face survey interviews were conducted in 30 locations across England and Wales which had previously been subject to flooding. Interviews were conducted in the autumn of 2002. Health impacts in those who had previously experienced flooding were measured using GHQ-12 and PTSS validated scales (completed twice, once with 'current' scores for assessing long-term health effects, and once using scores from participants 'worst time after flooding' for assessing short term health effects), and a self-reported health checklist. Statistical analysis was undertaken to explore three groups of factors that might influence these health effects: 1) Sociodemographic factors 2) Flood characteristics 3) Post flood factors **Results:** Broadly the results indicated that flooding causes both short-term physical effects and long-term psychological effects. The results of main health survey work as part of Phase 2 revealed that 23% (n=299) of the surveyed 'flooded participants' had received a flood warning. Participants estimated the warning time as 16 hours.	**Generalisability:** This study was undertaken in 30 previously flooded locations across England and Wales, and therefore the results are likely to be generalisable. **Methodological rigour:** Methodological quality assessed using the JBI critical appraisal checklist for cross sectional studies (comments on quality below): No major quality concerns for the phase 2 cross sectional study element of this report. Study robustly piloted using focus groups to develop surveys and then surveys piloted on smaller sample. Health effects were mostly measured in a valid and reliable way using validated scales (GHQ-12 and PTSS), however some data was collected for some questions via standard self-report which may be subject to recall bias.

		Bivariate analyses were conducted in order to investigate the relationship between flood characteristics, including receipt of warning and warning time, and health effects. It appears from the bivariate analysis that the receipt of a warning and warning lead time had little or no effect upon the long or short-term health effects of flooding. When the grouped PTSS Intensity and current GHQ scores of the warned and unwarned were compared, no significant differences were found. Comparison of the means of the current health effects measures confirmed that the receipt of a flood warning did not have a significant influence on the long-term health effects of the flooding as indicated by t-tests. *Long term health effects:* Warning lead times did not appear to influence significantly current health as measured by the grouped GHQ and PTSS Intensity scores. However, for those who received a warning, there were significant but weak negative correlations between the length of warning time and the scores. The long-term health effects were lower, the longer the warning lead time (Pearson Correlation for warning time and GHQ Likert scores and PTSS Intensity score -0.18 and -0.16 respectively). *Short-term health effects:* In terms of the short-term effects, the only statistically significant differences found were in the grouped GHQ Likert scores for the worst time of the flooding. More of those who did not receive a warning registered higher GHQ Likert scores for the worst time than of those warned. A comparison of the mean worst time GHQ scores of those who did and did not receive a warning confirmed that there were no significant differences in worst time scores. For those who received a warning, the grouped GHQ scores for the worst time of flooding did not vary significantly according to the number of hours of warning received. However, there were again very weak but statistically significant correlations between warning time in hours and the short-	

		term health effects of flooding as measured by the GHQ scores for the worst time and the self-reported health effects (Pearson Correlation: GHQ Likert for worst time -0.14, immediate physical health effects -0.22, longer term physical health effects -0.21, psychological effects -0.20). Conclusion: The research recommended that the value of £200 per household per year be taken as representing the benefits of reduced health impacts as a consequence of a significant reduction in the risk of flooding. A simple methodology for incorporating such benefits into the cost-benefit analysis of flood and coastal defence schemes is recommended and was applied to four case studies. The results from the case studies suggest that although the economic appraisal will tend to be dominated by the much larger 'tangible' losses (damage to property, etc.), the inclusion of health impacts will, in some cases, lead to the selection of options with higher standards of protection. Finally, it is recommended that consideration be given to the merits of undertaking further work to assess the health impacts on other groups who may be affected by flooding, with particular regard to the impacts on those who run small businesses (such as shopkeepers).	

Munro, A, et al., (2017). Effect of evacuation and displacement on the association between flooding and mental health outcomes: a cross-sectional analysis of UK survey data. *Lancet Planet Health,* 1:e134-41.	To examine the effects of evacuation and displacement due to floods in England on depression, anxiety, and post-traumatic stress disorder indicators.	**Study design:** Cross-sectional study. **Location:** England **Method:** In this multivariable ordinal regression analysis, data was collected from a cross-sectional survey undertaken one year after a flooding event from flood-affected postcodes in five counties in England. The analysis was restricted to individuals whose homes were flooded (n=622) to analyse displacement due to flooding. The primary outcome measures were depression (measured by the PHQ-2 depression scale) and anxiety (measured by the two-item Generalised Anxiety Disorder [GAD]-2 anxiety scale), and post-traumatic stress disorder (measured by the Post-Traumatic Stress Disorder Checklist [PCL]-6 scale). The analyses were adjusted for potential confounders. Duration of displacement and amount of warning received were also analysed. **Results:** People who were displaced from their homes were significantly more likely to have higher scores on each scale; odds ratio (OR) for depression 1·95 (95% CI 1·30–2·93), for anxiety 1·66 (1·12–2·46), and for post-traumatic stress disorder 1·70 (1·17–2·48) than people who were not displaced. The increased risk of depression was significant even after adjustment for severity of flooding. **Scores for depression and post-traumatic stress disorder were higher in people who were displaced and reported receiving no warning than those who had received a warning more than 12 h in advance of flooding (p=0·04 for depression, p=0·01 for post-traumatic stress disorder), although the difference in anxiety scores was not significant.** **Conclusion:** Displacement after flooding was associated with higher reported symptoms of depression, anxiety, and post-traumatic stress disorder	**Generalisability:** Participants were recruited from various parts of England. Therefore, results should be largely generalisable to the Welsh population. **Methodological rigour:** Methodological quality has been assessed using the JBI critical appraisal checklist for analytical cross-sectional studies. The study was found to be of good quality, although limited information was given on the type of warning system utilised, however this was not the main focus of the research.

		one year after flooding. The amount of warning received showed evidence of being protective against symptoms of the three mental illnesses studied, and the severity of flooding might be the reason for some, but not all, of the differences between the groups.	

Parker D., et al. (2005). Socio-Economic benefits of flood forecasting and warning. *International conference on innovation advances and implementation of flood forecasting technology,* Tromsø, Norway.	To discuss what is currently known about the socio-economic benefits of flood forecasting, warning and response systems (FFWRS).	**Study design:** Literature review **Location:** England and Wales **Method:** None described **Results:** In a recent large scale Defra/EA funded survey (RPA/FHRC, 2004), [it was found that] simply receiving a flood warning of some kind made hardly any significant difference to these self-reported physical or psychological symptoms and to short term and long term mental impacts. However, this UK study provides some evidence that a longer warning lead time has a mitigating effect on the mental health of flood victims at the time of flood and in the longer term. [...] Warning lead time emerged as one of ten factors that had an influence on mental health at the time of flooding as measured by the GHQ-12 scale. It was also one of ten factors influencing the current stress levels of flood victims measured by the PTSD Intensity score with a longer warning lead time associated with reduced mental health and stress effects. [It has also been suggested that] the increase in the coverage and effectiveness of flood warning systems may be the main cause of a negative correlation between flood incidence and loss of life in Europe over the past three decades. **Conclusion:** Research reveals the importance of primary intangible (protection of life) and secondary intangible (e.g. health) warning benefits, although our ability to estimate the latter remains limited. In Britain flash flood warning benefits are potentially important but we know little about the benefits of warnings providing less than 2 hours warning lead time, and this is an area of research need.	**Generalisability:** Some studies from the UK are discussed, and so the findings may be generalisable to Wales, but this should be explored further. **Methodological rigour:** This is a non-systematic literature review / commentary and is therefore inherently subject to bias (such as selection bias). They are also not necessarily comprehensive and so do not provide a full overview of the evidence base. Therefore, any results/conclusions from this review should be treated with caution. Methodological quality has been assessed using the JBI critical appraisal checklist for narrative textual evidence (comments on quality below): Narrative and conclusions reached appear credible, however: No detail on research methodology presented. No critique of included studies.

			Extreme caution should be exercised interpreting the results, due to the inherent risk of bias present in this research study design.

Stanley C, et al. (2023). The association between weather warnings and hip fractures in the Republic of Ireland. *Archives of Osteoporosis*. 18:53. Doi: 10.1007/s11657-023-01243-9	This study aimed to examine the relationship between hip fractures and weather warnings, with the hypothesis that higher rates of fractures occur during warnings.	**Study design:** Case crossover study **Location:** Republic of Ireland **Method:** A retrospective review of 7 years of data from the IHFD base and the Irish National Meteorological service was performed from Jan 2013 to Dec 2019. A statistical analysis of weather warning features and their relationship to hip fractures was then performed. Fractures and weather warnings were stratified by county with both a panel and case crossover analysis performed. **Result:** A comparison of weather warning by element was undertaken as a sub analysis. This found no statistically significant association between weather warnings with a flooding element and hip fractures, when analysed using panel analysis (incident rate ratio: 1.22, 95% CI: 0.76 to 1.94, $p < 0.414$), or case crossover analysis (incident rate ratio: 1.14, 95% CI: 0.67 to 1.92, $p < 0.635$). **Conclusion:** An increased incidence of hip fractures appears to occur during weather warnings, in particular yellow and orange weather warnings, while for the post severe red warnings, this increase may be deferred until the days after the warning. This has implication for planning of emergency department staffing, and consideration should be given when preparing for periods of extreme weather, ensuring sufficient resources.	**Generalisability:** Study undertaken in the Republic of Ireland. Health systems & weather warning systems may differ and so generalisability to Wales should be considered further. **Methodological rigour:** Methodological quality appraised using the JBI critical appraisal checklist for case control studies. However, study design is a case crossover (no corresponding checklist available for this design), and so participants serve as their own control group. This has meant that some questions on the checklist are not applicable. Both the exposure and the outcomes appear to be assessed in standard, valid and reliable ways. Confounding factors were identified and discussed, and statistical analysis was conducted to deal with these.
Yari A, et al. (2020). Risk factors of death from flood: findings of a systematic	This thematic systematic review aimed to investigate and categorize the	**Study design:** Qualitative systematic review	**Generalisability:** Included studies are from a range of countries, the majority of which are OECD

review. *Journal of Environmental Health Science and Engineering*. 18: 1643-1653. Doi: 10.1007/s40201-020-00511-x	underlying risk factors for flood death.	**Location:** The majority of included studies were related to the USA (n=12 studies), the Netherlands (n=8), Australia (n=6), Greece (n=5), England (n=4) and France (n=4). **Method:** Multiple databases were searched in September 2017 for studies meeting the review inclusion criteria (regardless of study design). Data was extracted, coded synthesised using descriptive and thematic analysis. **Result:** Forty-eight studies were included in the review. One hundred and fourteen risk factors were identified from these and categorized into five categories that can have an influence on flood deaths: hazard related factors, and individual, environmental, socioeconomic, and managerial categories. ***Lack of early warning system and warning time was identified as one risk factor for death from a flood in the thematic synthesis,*** *under the managerial category.* **Conclusion:** The study identified many factors that affect flood deaths. The variety and the diverse nature of the factors necessitate appropriate interventions for removing or reducing the effects of the identified factors. More quantitative analytical studies are needed to confirm causal relationship between extracted factors and floods death.	countries, with four from the UK. Generalisability should be explored further. **Methodological rigour:** Methodological quality assessed using the Evidence Service in-house qualitative systematic review critical appraisal checklist (comments on quality below). Authors state the review adheres to PRIMSA guidelines however these are less useful for qualitative systematic reviews as they are designed for quantitative reviews. Comprehensive range of databases searched. Search date limited, however justification for limits not provided. Reference list checks and grey literature search also undertaken. Study inclusion and exclusion criteria not clearly stated. No quality assessment of the included studies undertaken. Thematic analysis undertaken however findings are not

			supported by direct quotes from participants/studies – instead risk factors are just coded and categorised. Reflexivity not considered. Limitations not discussed.

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