Housing Quality and Health- an Economic Analysis

Report to Scottish Futures Trust and Public Health Scotland

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List of Acronyms

BRE	Building Research Establishment
CBA	Cost Benefit Analysis
CCA	Cost Consequence Analysis
CEA	Cost Effectiveness Analysis
HHSRS	Health and Safety Rating System
NHS	National Health Service
PHS	Public Health Scotland
PROSPERO	(International) Prospective Register of Systematic Reviews
SFT	Scottish Futures Trust
SHCS	Scottish House Condition Survey
SHQS	Scottish Housing Quality Standard

Executive Summary

This report aims to assess the economic impact of poor-quality housing on health outcomes in Scotland. Ultimately, it seeks to inform the ongoing critical discussion regarding housing as a determinant of health and driver of health inequalities, particularly concerning the impacts of good quality housing and the economic costs of poor-quality housing in the Scottish context to inform and influence the future policy and national health and housing strategies. Initially, this study reviewed recent literature exploring the connections between inadequate housing and health outcomes. Following this a systematic literature review was conducted, focusing on economic evaluations. This review aimed to reveal the types of economic assessments undertaken concerning poor housing, the variety of outcomes used to gauge the effectiveness of improvement interventions, and the available economic evidence which can be considered relevant to the Scottish context. Thirdly, a cost analysis was undertaken for Scotland, replicating the costing approach conducted in other UK countries.

Key findings from recent literature reviews on outcomes indicated a clear link between poor housing and significant health issues, specifically cold temperatures with cardiovascular disease and respiratory conditions, damp and mould with poorer respiratory health, overcrowding with infectious diseases and hazards/safety factors which impact on falls amongst the elderly. Interventions addressing warmth, energy efficiency, and environmental hazards demonstrated tangible improvements in health outcomes, a reduction in hospital admissions, and lower rates of falls among older adults.

The economic evidence review revealed considerable gaps in the existing data, highlighting a scarcity of comprehensive economic evaluations focused on housing quality improvements. The available data from the UK context suggests that retrofitting and council housing upgrades (e.g. from energy efficiency interventions, and improving building related risk factors) are likely to be cost-effective or cost saving, through preventing chronic and acute illnesses which subsequently burden the National Health Service (NHS). Evidence pertaining to the Scottish context was notably limited. Overall, the economic evidence indicates that policy efforts should focus on supporting and expanding retrofit and insulation programmes, particularly targeting elderly, low-income, and medically vulnerable populations. Furthermore, aligning housing improvements with public health objectives has the potential to deliver significant co-benefits, including reduced healthcare utilisation and improved wellbeing.

The Cost Analysis for Scotland estimated the annual NHS costs associated with poor housing conditions to be £530 million (ranging between £433 and £674 million). The one-off cost of mitigating[3] these hazardous housing conditions was estimated to be £7.7 billion. The report identifies significant limitations in the existing Scottish data, particularly with aligning the housing hazards from the Scottish survey, with those hazards defined and measured in the

[3] Cost of mitigation is the estimated one-off cost needed to rectify the existing category 1 hazards (identified in the surveys) to improve them to make them acceptable by Health and Safety Rating System (HHSRS) standards, e.g. so they would no longer classed as a category 1 hazard.

surveys in England, Wales, and Northern Ireland. In particular, the Scottish survey does not collect many of the hazards collected in the other UK national housing surveys.

This report shows the substantial financial implications of poor housing in Scotland. However, it also stresses the necessity for increased investment in research, including ongoing monitoring and evaluation, to enable more precise quantification of the costs associated with inadequate housing in Scotland. This improved understanding is crucial for informing future policy decisions regarding the extent and methods of investing in improving the quality of housing in Scotland.

Recommendations include enhancing future iterations of the SHCS to incorporate a broader range of hazard data and detailed housing stock characteristics. Furthermore, collaboration with housing and public health experts is crucial to refine methodologies for assessing housing-related health impacts. The report concludes with initial suggestions on how to initiate these next steps to gather the necessary evidence.

1. Introduction

The link between poor housing conditions and detrimental health consequences is long established (Marmot, 2010; 2020), impacting on people's physical and mental health and wellbeing through a range of housing aspects including availability, affordability, accessibility, quality, security, and community. Poor-quality housing is a driver of health inequalities (ScotPHO, 2024). Public Health Scotland has highlighted the importance of the link between inequalities and health, and propose that a healthy society which enables people to thrive is underpinned by key sectorial building blocks. Access to affordable, warm, stable and safe housing (good quality) is one of these key building blocks that need to be achieved in order to take a public health approach to prevention (Public Health Scotland, 2024; Scottish Government, 2025). The Scottish Government have also acknowledged the importance of housing quality impacts on the nation's health and wellbeing, and importantly the links to wider societal concerns with tackling child poverty and climate change. In 2021 the Scottish Government set out a new long term strategy titled 'Housing to 2040' to deliver better quality affordable housing to achieve their ambition that everyone in Scotland should have access to a warm, safe, affordable and energy efficient home (Scottish Government, 2021). The strategy emphasises that this housing ambition will have beneficial health impacts across society while also making an important contribution to tackling child poverty, homelessness and achieving environmental targets (Scottish Government, 2021). This 2040 housing vision has been embedded into their newly published Population Health Framework (Scottish Government, 2025), which sets out a 10 year plan with a strategic prevention focus; aiming to improve Scottish life expectancy whilst also reducing inequalities in life expectancy between the most deprived and the national average by 2035. The framework coordinates action with local and national stakeholders to ensure housing contributes to health improvements and reducing health inequalities.

While these policy ambitions are commendable, the Scottish Government declared a housing emergency in May 2024, and across the UK there remains an emergency level 'housing crisis' (Shelter, 2024), which needs to be addressed. This comes following over a decade of financial pressure on government and communities as a result of austerity. In addition, the more recent cost of living crisis, and the current restrained economic climate with budget cuts at both national and local levels affects the resources available to support government visions. In this context there are many competing sectors in need of the restricted public finances. Therefore, quantifying a value case including the potential savings in other areas by investing in good quality housing is needed to highlight the benefits across Scottish society so action can be taken to invest.

In Scotland, it was recently estimated that 2.3 million people are affected by the housing emergency, struggling with home conditions, security, suitability, or cost (Shelter, 2024). Some studies in the other UK nations have explored the social and economic cost of poor housing, quantifying the costs of not addressing the current hazards in poor-quality houses. For England, it has been estimated that treating people with illnesses caused by poor housing conditions costs NHS England £1.4 billion per year, (Garrett, et al. 2021), establishing an economic case for investment in good quality housing. There is no such equivalent cost analysis for Scotland.

There is a need to assess the impacts of good quality housing and the economic costs of poor-quality housing in the Scottish context in order to inform and influence the future policy and national health and housing strategies. In particular, an analysis costing poor-quality housing is important to support a case for investment in good quality housing (including social, affordable and private rented housing quality); and potentially suggest future work to inform how to invest (which interventions are effective and cost-effective at improving the quality of existing stock) at a time when scarce public resources are being further reduced and different parts of the public sector are competing for budgets. The overall aim of this work is about understanding the current evidence base and the potential costs of poor-quality housing and the potential benefits from preventative investment in good quality housing for Scotland.

1.1 Definition of Poor housing

The definition of poor housing differs across the UK and by different bodies. In England and Wales this is defined by a dwelling having one or more Category 1 Hazards as set out in the Housing Health and Safety Rating System (HHSRS). In Scotland, the Scottish Housing Quality Standard (SHQS) provides a benchmark called 'tolerable standard' for housing quality, considering that it is not reasonable to expect people to live in a house that does not meet this standard. Despite the lack of formal definition of 'poor housing' for Scotland, any dwelling classified below 'tolerable standard' could be considered of poor-quality housing.

1.2 Background

Much is already known about the links between poor housing and the negative impacts for health and wellbeing (Baker & Bentley, 2023; Thomson, et al. 2009; Palacios, et al. 2021). For instance, poor insulation and low indoor temperature could increase the risk of respiratory conditions; similarly, home injuries (accounting for a third of all injuries worldwide) are associated to hazards that can be eliminated or controlled with proper attention (WHO, 2018). However, additional evidence is needed to support local and national policy makers and funders to identify targeted interventions that are effective and cost-effective for investing in housing. There is a need for evidence in the Scottish context in order to drive, enable and action the future policy and Scottish health and housing strategies. The Building Research Establishment (BRE) Group has developed studies on the cost of poor housing for England, Wales and Northern Ireland, exploring (i) the associated cost burden to the NHS, (ii) the overall Societal cost (including the NHS, economic loss in productivity, social care) as well as (iii) estimating the one-off cost of mitigating the poor housing conditions (Garret, et al. 2021; Nicol, et al. 2018; Nicol et al. 2019). This exercise has not been done for the Scottish context. There are key differences in Scotland and the Scottish housing stock to those of the other UK nations, including different historical insulation standards, a wider range of different housing types, ages and materials across Scotland, and a more severe climate (Piddington, 2020; Congreve, et al. 2024).

Therefore, there is a need to get a clearer understanding of the likely costs and impacts of poor-quality housing and the costs and consequences of investing in (or mitigating the cost) of poor-quality housing in the Scottish context. Investment in new housing stock or improving existing poor housing could also contribute to achieving Net Zero ambitions and climate resilience. None of the other UK studies (Garret, et al. 2021; Nicol, et al. 2018; Nicol et al. 2019) have quantified these additional environmental gains in calculating the value of investing in good quality housing.

The overall aim of this work is about understanding the current evidence base and the potential costs of poor-quality housing and the potential benefits from preventative investment in good quality housing for Scotland.

1.3 Research Scope

This study aims to inform policy makers about the potential costs and impacts of investing in good quality housing that delivers better health and wellbeing outcomes for occupants. Given the time frame, budget and data availability, the scope of this work is a preliminary analysis based on a rapid evidence review of existing literature and data which aims to:

(i) Establish the current evidence on cost of poor housing as well as the wide range of benefits of good housing;
(ii) Identify the evidence gaps related to the Scottish context;
(iii) Undertake a cost analysis based on the current available data and evidence;
(iv) Inform next steps, such as design and development of a future study to address existing evidence gaps or improve methodologies or data, to better inform a value case for investment in good quality housing.

Undertaking primary analysis is out with the scope of this research, however it was intended that this study could inform and enable design and development of a future study.

The study was undertaken across the following stages:

1.3.1 Evidence Synthesis and Data Gathering

a. What is the **existing evidence** in Scotland, the UK and from other countries and context on impact and benefits of good quality housing?
b. What **outcomes** (health and other) have been used to assess 'effectiveness' or quantify the impact/benefits of poor and good quality housing? What is the strength and quality of the evidence? What are the evidence gaps?
c. What **economic evaluations** have been carried out in this context? What is the quality of economic evidence and what types of economic frameworks and methods have been used?

To answer these questions the study aimed to undertake rapid systematic evidence reviews on (i) existing evidence and the wide variety of outcomes (health and other) used to capture impacts/benefits of housing quality (ii) existing economic evaluations and evidence. The aim was to identify papers detailing the wide variety of outcomes/impacts and evidence to support these, including the impact on wellbeing and quality of life and wider social and economic impacts.

Additionally, we aimed to explore and access potential Scottish data sources: from Public Health Scotland (PHS) and Scottish Futures Trust (SFT) existing datasets, to identify which datasets (and their content) if any, are readily available, accessible and suitable to be included as evidence in a cost analysis. Through this work we aimed to establish any Scotland specific data sources which could be obtainable, which are currently unobtainable, and which could be incorporated into this and any potential future study.

1.3.2. Economic Analyses: Cost-Consequences and Cost Analysis

Economic analyses can take the form of various frameworks (Drummond, et al. 2015) including:

- (i) Cost-effectiveness analysis (CEA) which compare costs and outcomes measured in 'natural units', such as life years gained, cancers detected
- (ii) Cost-utility analysis (CUA) which compare costs and outcomes measured in terms of life expectancy adjusted for quality of life via a 'utility' measure, such as quality-adjusted or disability-adjusted life years (QALYs or DALYs)
- (iii) Cost-benefit analysis (CBA) which compare costs and health and non-health benefits valued in monetary terms. This can involve the measurement of non-health benefits across different sectors
- (iv) Cost–consequences analysis (CCA) which compares costs to health and non-health benefits across different sectors, measured in their natural units appropriate to the benefit being considered. In CCA the costs and multiple outcomes are reported in a disaggregated form, not combined into one single cost/outcome unit of measurement
- (v) Cost-analysis, considers costs alone and does not combine the costs with outcomes

For this project two distinct analyses were undertaken: (1) Cost-Consequence Analysis (CCA) based on published evidence and datasets identified in the systematic review and, (2) a Cost Analysis replicating the various BRE cost analyses for the Scottish context to estimate the cost to NHS Scotland associated with poor-quality housing. A CCA provides a summary of evidence, assessing a wide range of costs and consequences of an intervention or policy and its comparator, which enables decision-makers to have a comprehensive summary of the costs and effects, and direction of impact (positive and negative intended and unintended impacts) summarised separately.

1.3.3. Inform future study direction(s) detailing methodological developments to be addressed

The aim of this work was to reflect on the findings from the literature reviews, CCA and cost analysis, regarding the strength of the evidence base and whether or not a value case can be made for Scotland. Key questions addressed include:

- Reflect on the findings from the literature reviews and cost analyses regarding the strength of the existing evidence base
- Consider whether an economic case for investing in good housing was made from the body of work
- Consider what next: what (data, methods) are needed to inform a more robust analysis/ to strengthen the case for investment in Scotland?

Based on these findings alternative options to address the evidence gaps, methodological uncertainties and strengthen a value case for investment are proposed.

2. Evidence Synthesis and Data Gathering

This section details the development of the two distinct yet complementary literature reviews.

The first was an exploratory scoping review to map the existing evidence on the diverse array of outcomes employed to capture the impacts and benefits of housing quality improvements. In planning the search strategy for a review of existing evidence, we initially undertook an explorative look at existing literature for any recent reviews in this area prior to designing the scoping review strategy. This preliminary search found two existing systematic reviews with similar research questions that aligned with ours. One was a Cochrane systematic review published in a scientific journal (Thomson, et al. 2013). The other, a more recent rapid review which updated Thomson et al.'s literature search and additionally included evidence from grey literature such as relevant reports from policy and government organisations (Cullum & Long, 2024). Both aligned with our outcomes research question (see section 1.3.1a and 1.3.1b), and therefore rather than repeating the exercise, we analysed and summarise their findings.

The second was a rapid evidence review focused specifically on existing economic evaluations and economic frameworks utilised to assess interventions targeting poor housing (see section 1.3.1c).

Both literature reviews were intentionally broad in scope, examining global evidence and frameworks without restricting their focus to papers directly relevant to the Scottish context. The ultimate objective was to identify evidence that, while not immediately applicable to Scotland, could inform future methodologies, discussions, and reasoning for the Scottish setting.

2.1 Existing Evidence on Outcomes

A Cochrane review of evidence was published in 2013, which was a systematic review of the global literature to assess the health and social impacts on residents following improvements to the physical fabric of housing (Thomson, et al. 2013). The review was comprehensive and searched 27 databases from initiation up to 2010, but this broad remit also means they captured a very broad range of interventions from different international contexts, including historical housing interventions which have less relevance today. The systematic review identified 39 studies which met their criteria; 33 were quantitative, six were qualitative. We were interested in the range of health and non-health outcomes identified in the studies, the quality of evidence and that which could be relevant to the recent UK housing environment. The findings from this review have been useful for the current project. The key findings of the review are as follows:

- There is evidence that thermal/ heating improvements in the home can lead to health improvements, particularly for respiratory disease.
- Housing which is an appropriate size for the householders and is affordable to heat is linked to improved health and may promote improved social relationships.
- Provision of adequate, affordable warmth may reduce absences from school or work.

- Beyond warmth and size, evidence on outcomes was limited and of variable quality.
- There was some evidence on non-health outcomes (social relationships, economic gains through reducing work and school absences) although this was limited and less clear.

There have been no updates since the Cochrane review since 2013. As an explorative exercise we re-ran the Cochrane review search terms, in five of the most comprehensive databases: Medline (OVID), Embase (Ovid), Cochrane Library, Web of Science and Econlit, searching from 2010 to December 2024. This achieved an enormous number of initial returns, with over 120,000 from Web of Science, and 28,000 from Econ lit alone. Considering that the initial Cochrane review covered 27 databases, repeating this exercise was out with the scope of this project given the time and resource that would be required to complete it. However, an update of any recent evidence on outcomes from 2010 onwards was warranted.

While developing the search strategy we became aware of a rapid review of systematic reviews carried out by researchers at Manchester University (Long & Cullum 2024) that met the aims of this project and was already at an advanced stage. This review of systematic reviews explored the health impacts of poor housing. The evidence review aimed to explore (i) the evidence around the links between the housing condition and the physical and mental health of residents, and (ii) the evidence that different ways of improving housing quality and condition affects the physical and mental health of residents. The review used the Thomson et al. 2013 Cochrane review search strategy and terms, adapting and narrowing the scope to search two databases: Medline (Ovid) and the Cochrane Database of Systematic Reviews, followed by hand-searching in Google Scholar, Overton Index (a policy and grey literature database), and searching of independently commissioned reports on housing and health. This rapid review found 40 relevant systematic reviews, and identified three recent and relevant publications of NICE guidance (NICE: 2015, 2017, 2020). Given the two primary questions of the Long & Cullum 2024 review align with our Evidence Synthesis questions [(i) exploring the existing evidence and (ii) identifying the range of outcomes used and the quality of the evidence] we wanted to avoid unnecessary repetition of this most very recent review. Instead, it was decided to review the results and outcomes identified in the papers from the Thomson, et al. 2013 and Long & Cullum reviews. A summary of the findings from Long & Cullum 2024 is detailed below.

2.1.1 Summary of Findings from Long & Cullum 2024

The review identified evidence on 11 housing quality factors/elements across three broad areas which are associated with health consequences. A summary of these is detailed in Table 1 below under the three main areas: housing condition and design, indoor air quality and indirect evidence.

The authors used the Risk of Bias in Systematic Reviews (ROBIS) tool (Whiting et al., 2016) and Grading of Recommendations Assessment, Development and Evaluation (GRADE) (Guyatt et al., 2011) quality assessment tool to assess quality of the evidence. They summarised the certainty of evidence in the identified papers using the GRADE or a judgement based on their assessment of the GRADE considerations.

The strength of the evidence on the 11 factors was variable, with the strongest evidence pertaining to Cold indoor temperatures, Damp and mould; and Overcrowding. Cold indoor temperatures were evidenced to have health implications for cardiovascular health (e.g. increased blood pressure) and respiratory conditions (including asthma, wheeze, cough, cold, flu, breathlessness, upper respiratory tract symptoms, bronchitis). The evidence showed a link between cold homes and excess winter deaths from cardiovascular and respiratory conditions. Cold indoor temperatures were associated with increased blood pressure, reduced physical functioning, and poor sleep outcomes. Damp and mould had health implications on new cases of asthma and exacerbation of existing cases. Overcrowding was found to have health implications on infectious diseases and other studies linked overcrowding to depression. There was some weak evidence on lighting being associated with poor mental health and sleep quality, and some evidence that hazardous conditions are associated with falls in older adults.

Table 1: Summary of housing outcomes & evidence, adapted from Long & Cullum, 2024

Housing Factor	Health Outcomes (Evidence from 40 Reviews & 3 NICE guides)
Housing Condition and Design	
Cold indoor temperatures	NICE guidance highlighted the link between cold homes and excess winter deaths from cardiovascular and respiratory conditions. The evidence from one review suggests that cold indoor temperatures are associated with increased blood pressure, reduced physical functioning, and sleep outcomes. The evidence for associations with viral infections and Chronic Obstructive Pulmonary Disease (COPD) symptoms was inconclusive.
The built housing environment (building type and materials)	The evidence from three reviews suggests that aspects of the built housing environment/ fabric may be associated with increased asthma and poorer mental health, including depression. External environment/ traffic noise etc was considered separately and found to have limited evidence and uncertainty.
Housing age	The evidence from one review suggests that older houses may be associated with increased asthma symptoms in children, but the evidence for adults is inconclusive.
Home hazards	Specific home hazards were mostly unspecified in studies. Evidence from one review suggests that hazards within the home (in the bathroom and stairs) are associated with increased falls in older adults.
Inadequate light	The evidence from one review suggests that inadequate light is associated with poorer physical health, mental health, and sleep quality. Neighbourhood noise and impact on poorer sleep was noted in some studies, but the evidence was weak and assessed to be of low certainty.

Housing Factor	Health Outcomes (Evidence from 40 Reviews & 3 NICE guides)
Indoor Air Quality	
Indoor allergens	The evidence from one review suggests the relationship between various indoor allergens (e.g. house dust mite exposure) and asthma and wheeze in children is inconclusive.
Damp and mould	The evidence from five reviews suggests that there is an association between dampness and mould exposure in the home and new cases of asthma, exacerbation of existing asthma, increased wheeze, and poorer respiratory health. The impacts appear to be strongest in infants and children compared with adults. NICE guidance was identified and supports these conclusions
Lead exposure	No evidence identified. Two previous systematic reviews were identified, none of which included UK studies. The studies considered household measures for preventing domestic lead exposure in children <6 years old. There was no conclusive evidence.
Indirectly Relevant Evidence	
Housing tenure and precarity	The evidence from three reviews suggests that housing tenure and precarity are associated with increased anxiety and depression.
Overcrowding	The evidence from three reviews suggests that there may be an association between household overcrowding and various close contact infectious diseases (gastroenteritis, upper and lower respiratory tract infections, hepatitis A, tuberculosis, meningococcal disease, bacterial stomach infection, and trachoma) and depression.
Indoor pollutants and allergens related to residents' behaviour	Pet allergens: the evidence from one review suggests that the relationship between exposure to various household pets and childhood asthma is inconclusive. Domestic combustion and cleaning: the evidence from four reviews suggests that there is an association between exposure to indoor air pollutants from domestic combustion (e.g. volatile organic compounds) and household cleaning products with poorer health outcomes, including poorer respiratory functioning, asthma symptoms, COPD symptoms, and cancer. NICE guidance on the above noted that certain pollutants and pet dander are sometimes linked to respiratory, cardiovascular, and neurological symptoms.

The authors summarised that overall certainty in the current evidence base (of evidenced links between poor housing and health outcomes) is variable, however there is moderate certainty that houses with damp, mould, inadequate warmth, and inadequate air quality affect various aspects of respiratory health and cardiovascular health. The review also concludes that there is certainty in the evidence showing hazardous home environments are related to a greater number of falls at home. With regards to interpreting these findings, the variability in the evidence base is driven by poor or variable quality in the studies and that they were unable to demonstrate a definitive, causal link. The strongest evidence relates to Cold indoor temperatures, Damp and mould, and Overcrowding.

In terms of evidence regarding different interventions or different ways of improving housing quality and any evidence on how this can affect the physical and mental health of residents, this is summarised in Table 2. The strongest evidence related to interventions which tackle warmth and energy efficiency in housing, those that tackle hazards which can result in fewer falls, and those that tackle damp and mould which can improve asthma symptoms.

In terms of the strength of the evidence, these again showed a wide range of certainty. However, there was some certainty that interventions/approaches to reduce dampness, eliminate mould, improve warmth and energy efficiency, and remove environmental hazards can improve several physical health outcomes, including respiratory health, general physical health, and fall rates. The relationship between poor physical housing conditions and mental health was less clearly evidenced in the studies reviewed, however there was some evidence of moderate certainty that housing precarity and overcrowding are related to poorer mental health.

The evidence from the review shows that there is a need for more robust datasets and analyses to evidence causal links and strengthen the evidence base. There is high variability in the quality of the studies which impacts on their ability to evidence a causal link between housing condition improvements and a health benefit and on the certainty of the evidence base.

Table 2: summary evidence on interventions to improve quality and the resultant impacts on health of residents. Adapted from Long & Cullum 2024

Housing Factor	Health Outcomes (Evidence from 40 Reviews & 3 NICE guides)
Housing Condition and Design	
Warmth and energy efficiency	The evidence from four reviews suggests that warmth and energy efficiency interventions (e.g. the installation, upgrading, or reparation of central heating; the installation of insulation (roof, cavity wall, or both); the installation of double glazing; or a combination of these) improves the general health, asthma symptoms and respiratory health of adults and children. The impact on health outcomes of older adults was inconclusive, as was the evidence for the impact on mental health.
Retrofit	The content and nature of retrofit interventions was poorly described in the literature. It is possible that these interventions included many of the measures described above under Warmth and energy efficiency. The evidence from one review suggests that retrofit interventions may have a positive impact on general health but the evidence for effects on respiratory and mental health was inconclusive.
The built housing environment	No evidence
Housing age	No evidence
Home hazards	The evidence from 10 reviews suggests that interventions to improve home safety and reduce home hazards reduce the rate and number of falls when targeted at older adults who are at risk of falling. Provision of safety equipment appears to reduce injury rates in older adults. These interventions appear to have no

	effect on health-related quality of life, fall-related fractures, and falls requiring hospitalisation or medical attention.
Housing Factor	**Health Outcomes (Evidence from 40 Reviews & 3 NICE guides)**
Lighting	The evidence from one review on the effects of improving artificial home lighting on physical and mental health is inconclusive.
Indoor Air Quality	
Indoor allergens	The evidence from seven reviews suggests that various interventions to control indoor allergens (mostly house dust mites) had no effect on asthma, lung function or eczema outcomes.
Damp and mould	The evidence from one review suggests that reducing damp and mould in homes improves asthma symptoms and respiratory infections in adults, and reduces the number of emergency and inpatient hospital visits in children. The interventions did not improve asthma symptoms or respiratory infections in children or asthma symptoms in older adults.
Lead exposure	The evidence from two reviews suggests that household environmental interventions (namely dust control measures) did not affect blood lead levels in children. There were no studies considering lead pipes.
Indirectly Relevant Evidence	
Housing tenure and precarity	No evidence
Crowding	No evidence
Indoor pollutants and allergens related to residents' behaviour	No evidence

In terms of evidence on retrofitting, and neighbourhood renewal there was one systematic review (comprised of 14 studies, 10 of which were from the UK) giving evidence on this. The interventions in these studies involved government investment to improve housing conditions in relatively deprived areas, the interventions included warmth and energy efficiency measures (e.g. installation or upgrading of central heating), however they were not clearly reported and the interventions varied considerably across study populations and included wider neighbourhood changes and socio-economic regeneration activities. Among the relatively better-quality studies (five of the UK studies) beneficial outcomes included improvements in general health outcomes.

In the review the majority of included studies were conducted in North America, with the minority from the UK. There were no reviews or direct evidence from Scotland or Scottish studies. Additionally, the studies reviewed did not include any economic analyses or cost analyses, highlighting this evidence gap (albeit economic analysis was not the focus of these studies).

2.2 Economic Evidence Review

To address the evidence review Question 1.3.1c: 'What economic evaluations have been carried out in this context? What is the quality of economic evidence and what types of economic frameworks and methods have been used?' a review of economic evidence was undertaken.

As a first step, the PROSPERO register of systematic reviews was searched in November 2024 (https://www.crd.york.ac.uk/prospero/) to identify any ongoing or recently published systematic reviews of economic evaluations in housing quality improvement. No ongoing economic reviews were identified, however, it was noted that there were two ongoing systematic reviews of related broader interest (albeit out with the scope of our economic evidence review). The first was a systematic review exploring the impacts of housing quality improvements on mental health, undertaken by Australian academics (Shiels, et al. 2023). The second was a systematic review exploring the impact of housing instability on adverse pregnancy outcomes (Ditosto, et al. 2020). The latter has recently completed and should be due to publish shortly.

As noted above, the Long and Cullum review (2024) did not identify any evidence from Scotland or Scottish studies, and there was no economic evidence included in the reviews.

A preliminary search of the literature (prior to finalising the search strategy) identified one previous systematic review of economic evidence undertaken by Fenwick and colleagues in 2013 (Fenwick, et al 2013), as part of the broader Cochrane systematic review (Thomson, et al. 2013). The authors found 25 relevant studies reporting on housing quality interventions which had reported cost data and/or benefits to the recipients. Only 11 studies reported data which was considered amenable to economic evaluation and only four undertook an economic evaluation. Three of these were cost-consequence analyses, presenting the typical 'balance sheet' approach (whereby costs and a wide array of consequences are presented in a table format) and reported that the beneficial consequences would likely outweigh the intervention costs. The other study was a cost-effectiveness analysis which indicated the intervention was more costly and less effective than the status quo. A critique of the study was that it was poorly reported.

There is a lack of economic evidence on interventions aimed at improving housing quality, and we found no existing or ongoing reviews of economic evaluations since 2013. Therefore, we undertook a rapid review of economic evaluation of housing quality improvement studies to provide a more recent overview of the evidence (following Fenwick 2013), to identify existing evidence gaps, assess the types of evaluations and quality of these, and potentially to help inform the cost-consequence analysis.

2.2.1 Methods

2.2.1.1 Search strategy

We adapted the subject topic search strategy from the published Cochrane review (Thomson, et al. 2013), e.g. the housing and improvement terms, and combined them with economic evaluation filters to identify economic evaluation studies published in the past 20 years. We used the validated economic evaluation filters from the SIGN methodology search filters. The time horizon of 20 years was set to capture recent studies which are more relevant to present housing conditions/ factors (as opposed to historical approaches). We searched the following databases: Medline (Ovid), Embase, the Cochrane library and Econlit. The searches were limited to identify studies published in English only. The complete search strategy is attached as Appendix 1.

2.2.1.2. Eligibility criteria

We included economic analyses that were both partial (costing studies only) or full economic evaluations for any home improvements and studies evaluating the cost of illness due to poor housing. Studies published in languages other than English were excluded. We excluded studies without any economic component.

2.2.1.3. Study Selection

After removing duplicates, three reviewers shared the screening of titles and abstracts for inclusion. Of the total titles and abstracts screened, 20% were screened by two reviewers to check for discrepancies. As per Cochrane guidance, if more than 20% of these were found to have discrepancies in agreement for inclusion then it was planned that all papers (100%) would be screened by two reviewers (Nussbaumer-Streit, et al, 2023). A similar approach was used for the full texts screening of potentially eligible studies. Disagreements were resolved through discussion with all three reviewers. The double screening process revealed 8% discrepancies in the double screening (which was resolved by discussion amongst all three reviewers) and therefore 100% double screening was not necessary.

2.2.1.4. Data Collection

We used a standardised data collection form, and one reviewer extracted the data from the included studies. Data from 20% of the studies was checked by a second reviewer for any discrepancies or errors. We developed a data extraction form in Microsoft Excel and extracted information from each study on the study characteristics, type of intervention, data source, study methods, economic methods, model type, economic results and sensitivity analyses.

2.2.1.5. Data Synthesis

We conducted a narrative synthesis due to heterogeneity in populations, interventions, comparators, and settings and summarised results in structured tables and grouped by relevant characteristics.

2.2.2. Results

The electronic searches identified 4804 records of which 41 were identified for full text screening. Excluded studies were either (i) not economic evaluations or costing studies, or (ii) were not evaluations of housing quality improvement interventions. After full text screening, 11 were excluded, three of which were unable to be obtained and eight were broader economic analyses (e.g., burden of disease) not focusing on home improvements or cost of illness explicitly associated to poor housing. 30 studies were found eligible for inclusion. Figure 1 summarises the PRISMA flow chart for identified and selected papers.

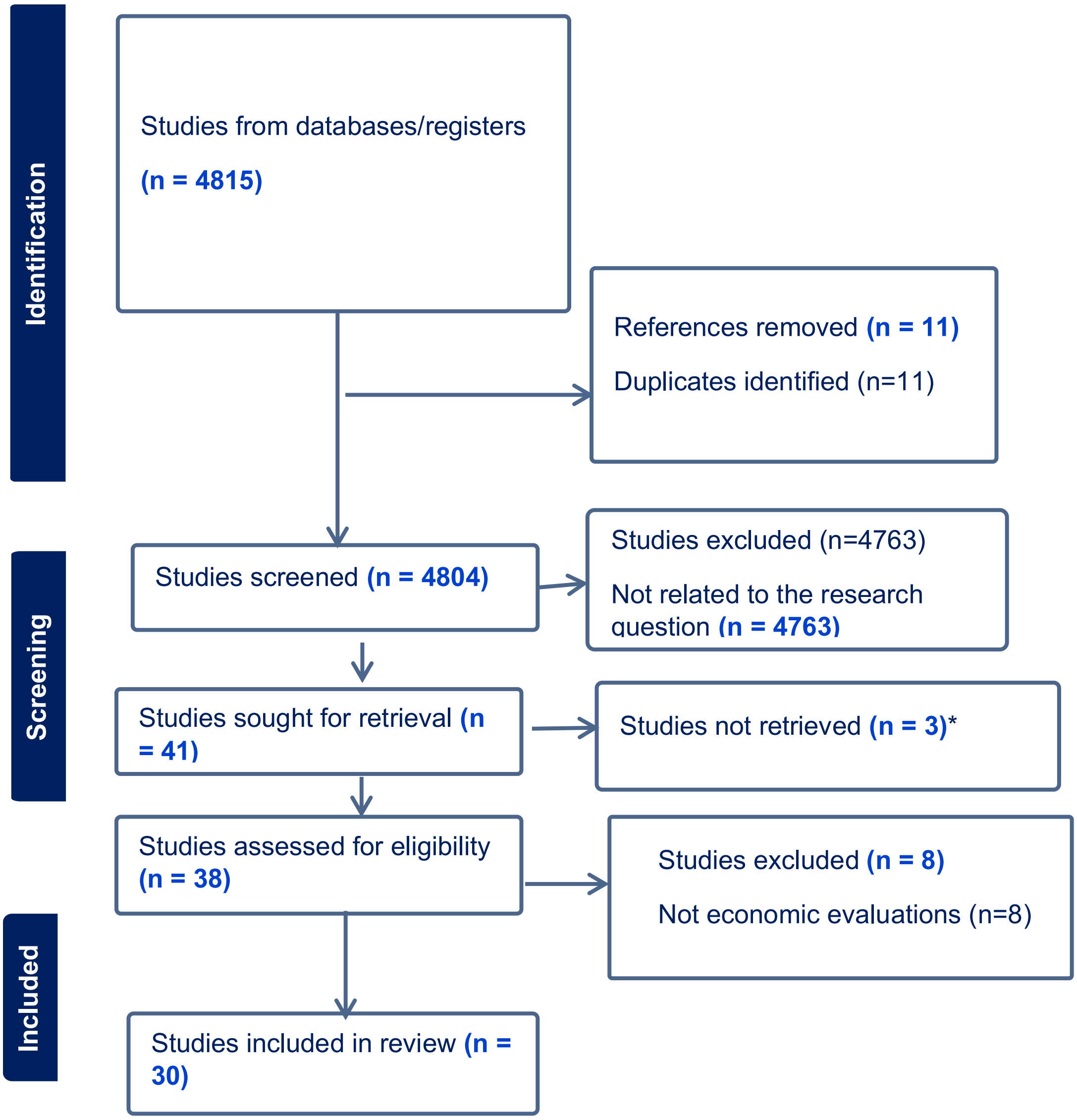

Figure 1: PRISMA Diagram of study selection

*full text unavailable

Appendix 2 details the references and summarised data extraction table for the 30 included studies, summarising the study characteristics, type of economic evaluation, data sources, economic methodology, results and author conclusions. The table has been imported into word as a text table format, however it is long and has therefore been appended (Appendix 2.1) to the end of this document rather than inserted as tables in the main text. The full Excel database of extracted summary data is available upon request. Quantitative synthesis on outcomes is inappropriate due to the heterogeneity in the studies, interventions, cost years, perspectives and outcome data. The results are not amenable to meta-analysis and have been narratively described in Appendix 2 and in the summary below. While the data from the reported studies are highly variable some of this evidence may be useful to the UK and Scottish context and for future modelling studies, and the results have been summarised as a cost consequence balance sheet for Section 2.1 cost-consequence analysis (Table 4).

The majority of economic studies were undertaken in the UK (9), followed by Canada (4) China (4) and Hong Kong (2), USA (3), Australia (2) and New Zealand (3). Sweden, Pakistan and Hungary each had one study. The majority of studies focused on quality or housing improvements in radon protection/remediation, household air filtration and ventilation improvements, housing upgrades or retrofits, and addressing issues related to overcrowding.

From the UK studies, six were focussed on radon reduction policies or strategies (Denman et al., 2005; 2008); (Coskeran, et al. 2005, 2006, 2007, 2009) using model based simulations to assess cost-effectiveness of reducing radon levels and reporting them to be cost-effective. Radon is a naturally occurring radioactive gas which can seep into homes and workplaces through the ground and if there is poor ventilation this can lead to high radon concentrations in indoor environments. There can be substantial detrimental health impacts of this, most notably with risk of lung cancer (WHO, 2023; UK Health Security Agency,2023).

One UK study was concerned with energy efficient retrofits to home boilers and windows (Bray et al., 2017), where the authors undertook a cost consequence analysis based on before/after survey data, reporting a cost of £3725/household with self-reported improvements in heating satisfaction in their homes and reduced health care visits. Dymond, et al. (2021) also considered home retrofits via interventions designed to reduce exposure to indoor air pollution in dwellings of varying building-related risk factors and profiles. They undertook a modelling exercise to explore alternative effectiveness and cost thresholds at which the potential interventions would be considered cost-saving (Threshold Analysis). Interventions were likely to be cost-saving e.g., at £50 cost, a 2% asthma symptom reduction could yield a £6.4million NHS saving in high-risk small homes. Interventions were generally found to be potentially cost-saving, through avoiding NHS related costs e.g. saving £356million in avoiding asthma related hospital visits over 5 years.

The final UK based study was a cost-consequence analysis undertaken in Wales, exploring the costs and outcomes of council housing upgrades (Rodgers et al. 2018). Various improvements and some co-improvements were explored (e.g. Electrical upgrades, insulation, heating, garden paths, new kitchens, bathrooms, windows/doors) in order to improve the homes to meet the Welsh Housing Quality Standard (WHQS), at a total cost of £138million. Reduced NHS accident and emergency admissions was the key quantifiable outcome (for cardiovascular conditions, respiratory conditions and fall and burn injuries). The authors assigned an NHS cost for avoiding admissions for each of the improvements/co-improvements. The installation of electrical upgrades delivered the greatest number of admissions saved per 1000 persons per year (57 admissions) and the greatest estimated savings per 1000 persons per year (£198,455). Windows and doors (£147,569), wall insulation (£127,215), and garden path improvements (£137,392) all resulted in NHS cost savings per 1000 persons per year. The evidence on whether improvements to loft heating, kitchen and bathroom improvements impacted on NHS admission was uncertain (the 95% confidence intervals crossed zero). The authors didn't translate the NHS cost savings per 1000 persons per year to a total annual cost saving, but this could be done if figures were known for the total population living in poor housing which could be improved by these interventions.

Overall, from the 30 studies, the evidence shows that outcomes assessed from warmth improvement studies include general health, respiratory health, mental health and hospital admissions. These can and have been converted into monetary values in the studies. Studies focussed on crowding used outcomes such as usable space, increased privacy, improved social relationships, which are not readily incorporated into full economic evaluation. However, as these outcomes can have resultant impacts on absences from work or school due to ill health, these could potentially be quantified into costing studies.

Figure 2 below summarises the type of economic evaluation framework used in the identified studies. The majority of economic analyses were cost-effectiveness or cost-benefit analyses, with many studies taking some form of costing study (CCA, costing, return on investment, multi criteria decision analysis), the majority of which took a societal or public health perspective (i.e. incorporating broader costs to society beyond the NHS, such as the cost to public or society from time off/away from work). This focus on costing studies (as opposed to cost effectiveness (CEA) or cost utility analyses (CUA)) is likely due to the wide range of relevant outcomes. A CCA may be more appropriate to reflect these as opposed to CEA and CUA which use one primary health outcome. However, the use of CCA may indicate the variability in quality and availability of data to enable a more robust economic analysis.

The broad economic perspectives taken is not surprising given the current context of 'housing improvement' where the impacts may be beyond immediate direct health impacts. It should be noted that a broader societal perspective is more likely to find interventions cost-effective or cost saving. Such perspectives will likely include the cost savings accrued not just by one individual, but by their dependants/all those dwelling in the house as well as inclusion of multiple outcomes which may have been monetized, (as opposed to a more typical payer perspective). So, while CCAs and CBAs taking a broad societal perspective are more appropriate evaluation tools in this space given the wide array of outcomes, co-benefits and impacts within and beyond the NHS, these analyses also lend themselves to cost-saving conclusions. The CBAs, costing studies and CCAs all evidence benefits to the NHS and beyond, for investing in housing improvements, and many show cost saving potential. However, the CCAs do not enable a decision on cost-effectiveness, but leave this up to the decision maker to consider and trade-off the various impacts against the potential costs.

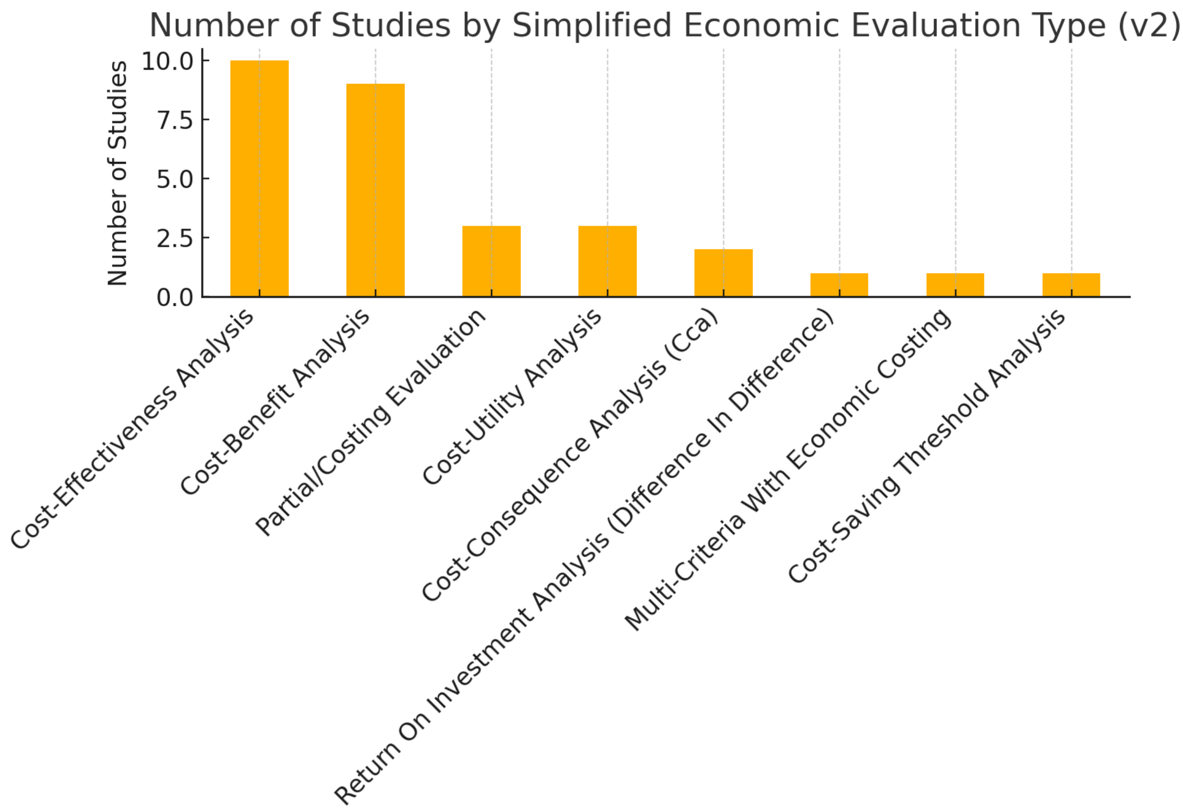

Figure 2: Summary of Economic Evaluation type

2.3 Evidence from the UK: BRE Reports

To assess the cost of poor housing due to its impact on health, the availability and coverage of data on housing and health is essential. As previously mentioned, in the UK, BRE Trust estimated the poor housing cost for England, Wales and Northern Ireland. In addition to considering the evidence from (i) Thomson et al., 2013, and (ii) Long and Cullum 2024, and (iii) the economic evidence review detailed above, we reviewed the three BRE reports from across the UK (Garrett, et al. 2021; BRE 2018; Nicol, et al. 2019); and considered the data embedded within these surveys, and the cost (or economic) analyses undertaken in these reports.

Table 3 below summarises a comparison of the three BRE reports comprising the ‘cost analyses’ of poor housing for the three UK countries.

Table 3: Summary of BRE Surveys across the UK

Characteristics	England Garrett, et al	Wales Nicol et al.	Northern Ireland Nicol et al.
Publication-year	2021	2019	2018
Data-year	2018	2017-18	2016
Number of household hazards considered in analysis	26*	29	26
Source of hazard data	English Housing Survey (EHS)	Wales Housing Condition Survey (WHCS)	Northern Ireland Housing Condition Survey (NIHCS)
Analysis Method	Cost Analysis	Cost Analysis	Cost Analysis
House with poor conditions (%)	15	18	9
Cost of Poor Housing			
Cost to NHS (£/year)	1.4 billion	95 million	40 million
Cost to Society (£/year)	18.5 billion	1 billion	401 million
Cost to Mitigate Hazards	9.8 billion	584 million	305 million
Payback period-NHS perspective	7-8 years	12.8 years	8 years
Payback period-Societal	1 year	5 years	0.8 years

* Asbestos; biocides, volatile organic compounds not measured in EHS.

All three BRE reports have data from their country specific housing surveys, covering between 26 to 29 hazards, to which a cost was applied.

BRE Trust calculated the poor housing cost for England, Wales and Northern Ireland linking each of the 26 or 29 hazards defined by the Housing Health and Safety Rating System (HHSRS) with information from their national house condition surveys. Hazards are related to the housing design and condition and exclude all risks from occupier behaviour (e.g., exposure to cigarette smoke, exposure to dust etc.). Based on the risk extent, each hazard in every house is then categorised as category 1 or 2, where category 1 is the immediate risk to a person's health and safety, and 2 is any lower extent. According to HHSRS, any house assessed having a category 1 hazard can be classified as poor housing.

The costs to the NHS presented in Table 3 are the estimated NHS cost of treating the 26 or 29 hazards, given the data/number of category 1 incidences reported in the respective surveys, the related NHS admission/health problem and the cost of treating it. The societal cost includes the NHS cost plus the economic loss in productivity (time away from work due to the hazard). The BRE methodology was to identify key housing factors contributing to the hazard, linking them with the main health repercussion linked to the hazard and the extent of such link; and then secondly, a costing exercise to (1) estimate the NHS system cost to treat conditions related to the housing hazard, followed by (2) estimating a 'mitigation' costs to improve the category 1 hazard to a category 2 hazard. Hence the pay-back period detailed in Table 3 relates to the time it would take to break even/ account for the one-off expenses of hazard mitigation, e.g. to offset the NHS savings from avoiding the hazards.

Cost of mitigation in the BRE reports is the estimated one-off cost needed to rectify the existing category 1 hazards (identified in the surveys) to improve them to make them acceptable by Health and Safety Rating System (HHSRS) standards, e.g. so they would no longer be classed as a category 1 hazard, but as a category 2 hazard. It is the cost of the necessary structural and internal adjustments required to address the hazards and improve them to a minimum acceptable standard (category 2). It is not a cost for the home-owner, but a societal cost related to the specific hazard and the work that would be required to address and amend the hazard to an acceptable minimum standard. The NHS costs reported in Table 3 represent the total annual cost to NHS or to society. If you divide by number of hazards (detailed in the respective surveys, and in BRE reports) it is possible to calculate the average cost per hazard.

2.4 Scottish Data Source: Scottish House Conditions Survey (SHCS)

The benchmark for acceptable housing in Scotland's social rental sector is the Scottish Housing Quality Standard (SHQS). This standard mandates that social housing providers guarantee their tenants' residences are energy-efficient, safe from hazards, structurally stable, and equipped with well-maintained kitchen and bathroom facilities. While only social landlords are legally bound to adhere to the SHQS, the Scottish House Condition Survey (SHCS) gathers information across all housing types and tenures to enable comparative analysis.

SHCS is Scotland's largest housing research project and only national survey assessing both the physical state of homes and residents' experiences. For this reason, it was chosen as the primary data source to undertake a Cost Analysis replicating the BRE method for Scotland.

The original SHCS's aims are to: (i) monitor national housing stock quality over time; (ii) understand factors influencing its condition; (iii) provide a benchmark for local surveys; (iv) inform Scottish Government resource allocation; (v) explore links between investment and stock condition; and (vi) offer data for housing policy development (e.g., fuel poverty). Since 2012, the SHCS has been a module of the Scottish Household Survey, maintaining its sampling procedures and reporting frequency (annual key findings, triennial local authority reports). Data collection involves a social interview with a high-income householder and a subsequent physical inspection by a building professional, covering household details, dwelling characteristics, condition, amenities, and compliance with standards. The survey targets all housing types across Scotland using a stratified random sample. Sample sizes have varied, with around 3,000 paired cases annually before 2020 (when the survey was paused) and 5,501 in 2022. Data is collected via face-to-face computer-assisted interviews and electronic physical inspections.

3. Cost-consequences and Cost Analysis

The costing analyses for this study is undertaken and presented in two different ways:

1. A costs and consequence analysis as a summary of the existing evidence from the economic evidence review, summarising the housing quality improvement intervention type, cost and outcomes reported by each of the 30 economic studies identified in the evidence review in section 2.2 of this report.

2. A preliminary cost analysis undertaken to replicate the analyses in the previous BRE reports from the Scottish context. The aim was to replicate the methods used in the BRE reports for each of the countries but utilise the Scottish data from the SHCS 2023 dataset and enable a Scottish cost matched to the variables used in the BRE analyses, for price year 2023. It should be noted that this analysis was limited to Scottish data on only the nine hazards out of the 26 used in the BRE reports. There were only nine hazard variables (identified in section 3.2 and Table 5) from the SHCS which match the data/variables used in the English Housing Survey (EHS); Wales Housing Condition Survey (WHCS) and Northern Ireland Housing Condition Survey (NIHCS), used to inform the BRE analyses.

3.1 Cost-consequence analysis summary

Table 4 below summarises the costs and results from the 30 economic studies identified in the economic evidence review. Note the costs are as reported within each study, in the currency used for the original analyses and have not been converted to price year 2023.

To note, all studies identified / concluded that the interventions were either cost-effective or cost saving, despite some substantial investment required. The broad perspective adopted in these studies has helped support these conclusions, enabling cost off-setting through monetising multiple outcomes. However, none of the studies considered unintended consequences or health harms as a result of the interventions evaluated. Most studies are focused on the cost-effectiveness, benefits, or protective health impacts of housing interventions.

Only Denman et al. 2008 (a study modelling alternative Radon Action levels) found that additional efforts to reducing the Radon Action Level below 200 Bq/m³ would prevent more cancers but be less cost-effective. The authors concluded that a higher range between 200–300 Bq/m³ is the most efficient range.

Further discussion on the summary results is provided after Table 4.

Table 4: Cost-consequence balance sheet from Economic Evidence Review

Study	Country	Year of Costing	Intervention Type	Costs	Consequence / Impact
Baird et al., 2020	USA (Pittsburgh)	Not specified	Public-private HOPE VI reinvestment in low-income neighbourhood	$10M investment	Significant positive effects: but cities should anticipate gentrification-related displacement
Aldred et al., 2015	United States	2007	HVAC system with a commercially available activated carbon (AcC) filter		Benefits are skewed, with the largest gains in older adults and those with respiratory conditions.
Babu et al., 2007	India (Orissa)	Not specified	Household-level use of personal protection measures (PPMs), including coils, vaporizers, sprays, smoke, and untreated bednets	Mean monthly expenditure: •Urban: ₹101 (USD ~$2.20) •Rural: ₹72 (USD ~$1.60)	High usage of mosquito protection; significant household cost burden; need for safer, affordable options and improved public mosquito control efforts
Bray et al., 2017	UK	2010	Energy-efficient retrofits (boilers, windows)	Mean intervention cost = £3725.26	May be cost-effective in older populations despite modest short-term NHS savings.
Bai et al., 2017	China	2015	Structural Insulated Panels (SIPs) in rural construction	Initial Investment (¥/m²): SIPs – ¥1050; Brick – ¥750 (lowest) - Life Cycle Cost	SIPs offer superior economic and carbon performance among alternatives

				(¥/m²/year): SIPs – ¥33.03 (better than brick: ¥41.98)	
Coskeran et al., 2006	UK	2003	Radon protection – membrane and sump (current) vs. post-construction testing and remediation (alternative)	Average Cost per QALY gained reported: £2869 (alternative) vs. £6182 (current). below NICE threshold; worst-case still cost-effective	The alternative regime is more cost-effective than the current approach; policy should consider targeted remediation post-construction. It is inappropriate to report Average cost-effectiveness ratios as done here, but the ICER can be calculated, giving £708/QALY well below the NICE threshold so can be considered cost-effective.
Chau et al., 2008	Hong Kong	2006	Air cleaners, behavioural changes, and relocation	Max CBR: 2.1 (elderly, air cleaner in cool season); max individual benefit: HK$2072 (adult), HK$1700 (elderly); relocation benefits lower	Mechanical ventilation (Air cleaners) with windows closed, especially in cool season, offer highest health and economic benefits. Resident behaviour (e.g., window opening) significantly affects outcomes.
Coskeran et al., 2005	UK	2002	Radon remediation in homes (Fan-based radon extraction systems installed in homes >200 Bq/m³)	Cost per life-year gained: £5,387–£7,770 (3% discount), all <£30,000 threshold; BCR >1 in some PCTs; cost-effective under NICE/Gerber–Phelps criteria	Radon remediation in homes is cost-effective for health gains. Higher remediation rates and targeting high-radon areas improve cost-effectiveness. PCTs should promote remediation in affected areas.

Coskeran et al., 2007	UK	Not specified (Based on 2004 values)	Radon-proof membranes in new homes	Base case: £6,182/QALY gained; Best case: £1,893/QALY; Worst case: £56,531/QALY; Still cost-effective under NICE threshold	Installing radon-proof membranes is cost-effective in high-radon areas and compares favourably with other health interventions.
Coskeran et al., 2009	UK	2006	Various radon protection strategies (membranes, sumps, post-construction testing)	Cost per QALY: No radon protection during construction (£2870), Option install a radon membrane only during construction (£3026), Option Install both a radon membrane and a sump (£4286), Option Install both a radon membrane and a sump with limited testing and remediation (£4580), Option Current regulatory regime (£6182); all but Current regulatory regime cost-effective under NICE threshold	Alternative regulatory regimes (esp. post-construction testing with selective remediation) are more cost-effective than the current approach; support for policy change toward mandatory testing post-construction.
Denman et al., 2005	UK	2003	Radon testing and remediation (fan-based systems)	Cost per lung cancer averted (annualised): £963 (1997 est.) to £29400 (2003 min est.); Annualised cost per lung cancer averted in	Radon remediation is cost-effective in high-risk areas with high remediation uptake. However, uptake is low, and those remediating are often at lower risk.

				current population: £527k–£1.3M; Cost per life-year gained: £17,155 (2001 prices)	
Dymond et al., 2021	UK	2019	Both Home Retrofits and behavioural interventions	Interventions could be cost-saving depending on cost-effectiveness thresholds. E.g., at £50 cost, a 2% asthma symptom reduction yields £6.4M savings in high-risk small homes. At 10% effectiveness and 50% implementation, free interventions could save £356M (asthma), £240M (GAD), £223M (rhinitis), and £165M (COPD) over 5 years.	Interventions to reduce indoor air pollution can be cost-saving, especially in high-risk homes. Effectiveness and risk profile are the strongest predictors of cost-savings
Chapman et al., 2009	New Zealand	2004-2005	Retrofitting insulation in low-income housing	BCR = 1.87 (5% discount), 1.59 (7%); NPV = NZ$1574/household; majority of benefits from reduced hospitalizations	Insulation retrofits are cost-beneficial with health, energy, and environmental co-benefits; compelling case for public investment
An et al., 2007	China (Guizhou Province)	Not specified	Stove replacement and health education to reduce arsenic exposure	10,000 stoves installed at ~$500k; urinary arsenic dropped significantly	The study demonstrates that targeted health education, combined with low-cost home improvements and policy support, can effectively

					reduce environmental health risks in low-income communities.
Denman et al., 2008	UK	2003	Radon remediation at varying Action Levels (e.g., 125–500 Bq/m³)	Cost-effectiveness varies by Action Level. At 200 Bq/m³: ~21 lung cancers averted/year in Northamptonshire; cost ~£130,000. Lowering the Action Level to 125 Bq/m³ increases cost (~£203,880) but prevents more cancers (~32). However, cost-effectiveness declines below 200 Bq/m³ due to diminishing returns.	Reducing the Action Level below 200 Bq/m³ prevents more cancers but is less cost-effective. 200–300 Bq/m³ is the most efficient range. Supports current UK Action Level policy while noting public uptake and equity challenges.
Gaskin et al., 2019	Canada	Not specified	National radon policy scenarios in new and existing housing	ICERs vary by scenario; best = passive + mitigation: <$25K/QALY	Mitigation is feasible and cost-effective across most provinces; supports incentives
Gaskin et al., 2020	Canada	2016	Radon mitigation in existing housing using two modelling techniques	Discounted ICERs ($/QALY): - Markov model: $72,569 (200 Bq/m³), $68,758 (100 Bq/m³), $93,007 (50 Bq/m³) - DES model: $84,828 (200 Bq/m³), $76,917 (100	Radon mitigation in existing housing is cost-effective in Canada, especially at increased testing/mitigation rates. Minimal structural uncertainty exists between model types. Public policy should consider promoting

				Bq/m³), $101,755 (50 Bq/m³) Lower ICERs with increased mitigation under tax credit scenario: as low as $54,621 (DES at 200 Bq/m³)	mitigation to reduce lung cancer burden.
Rodgers et al., 2018	UK	Not specified	Housing upgrades to meet Welsh Housing Quality Standards (WHQS)	Electrical upgrades associated with £198,455 savings per 1000 people (≥60) annually. £138 million invested in interventions. Significant reductions in emergency admissions for older adults linked to electrical, wall insulation, windows/doors, and garden paths. No significant effects for kitchens, bathrooms, or heating.	Targeted housing improvements (particularly electrical, insulation, and safety upgrades) reduced emergency hospital admissions and healthcare costs. Longitudinal evidence supports continued investment in quality housing for health improvement.
Gaskin et al., 2021	Canada	2016	Radon mitigation: improved foundation membrane in new housing; mitigation in existing homes at 200 or 100 Bq/m³	ICERs for new housing: $18,075–$58,454/QALY (except Nunavut: $340,482/QALY); ICERs for existing housing: $33,247–$61,960/QALY at 200 Bq/m³; More lung cancers averted in new housing (446 annually); Cost-effective in	Radon interventions are more cost-effective in new housing than in existing housing. Policy should support increased resistance measures in new construction and targeted remediation in high-radon areas.

				new housing across most regions; existing housing cost-effective in high-radon areas at 200 Bq/m³ threshold	
Riggs et al., 2021	New Zealand	Not specified	Housing quality improvement (modelled as counterfactual to poor conditions)	Annual cost of unsafe housing: ~NZ$1 billion - Mortality cost (VSL): NZ$939M/year - Hospitalization: NZ$36M (damp), NZ$2.3M (cold), NZ$1.4M (crowding) - ACC injury claims: 115,555/year; NZ$102.3M/year	Poor housing imposes substantial health and economic burdens in NZ. Damp/mould and fall risks are key contributors. Significant savings and health gains could be achieved through targeted housing improvements.
Robinson et al., 2021	Australia (Armidale)	2019	Reduction of wood heater pollution	GEMM: 14 premature deaths, 210 YLL, $32.8M/year cost (95% CI: $27.0M–38.5M) HRAPIE: 6.7 deaths, 90.4 YLL, $14.8M/year cost	Wood heater pollution in Armidale causes substantial health and financial burden. Effective policies are needed: public education, financial incentives for cleaner heating, regulations restricting wood heater use.
Fisk et al., 2017	United States	2015	Improved filtration in residential and commercial HVAC	Cost-to-benefit ratios ranged from 3.9 to 133 depending on intervention	Filtration improvements in homes and commercial buildings are highly cost-beneficial. Policy should

			systems, use of portable air cleaners	and location. Portable HEPA cleaners had the highest benefits. Mortality reductions up to 2.4 deaths prevented per 10,000. Annual monetary benefit per person ranged from $110 to $2,025 depending on the scenario.	promote minimum filtration standards and home use of HEPA cleaners, especially for older adults.
Keall et al., 2017	New Zealand	2010	Home modifications to reduce fall hazards	Cost per injury prevented: $980 (NZD 2012) Benefit-cost ratios: 8 (DALY-based) and 37 (VOSL-based) for 33% injury reduction For 26% reduction: BCR = 6 (DALY), 29 (VOSL)	Home modifications significantly reduce fall injury costs. The intervention is highly cost-beneficial under both DALY and VOSL models. Policy should support scaling of this intervention, especially for older adults and those with prior falls.
Liu et al., 2021	China	2009	Use of indoor air purifiers to reduce ambient PM2.5 exposure	Deaths avoided: 93,200 (S1) to 207,900 (S4) Net benefits: 131B RMB (S1), 90B (S2), –60B (S3), –317B (S4) BCRs: 2.6 (S1), 1.5 (S2), <1 in S3 and S4	Air purifiers can be a cost-effective, interim solution to mitigate PM2.5-related mortality in China. Scenario S2 (25 μg/m³) is optimal with national net benefits. Government support is necessary to ensure equitable access.

				S2 (PM2.5=25 μg/m³) recommended as most cost-effective national target	
Mishra et al., 2023	Australia	2021	Eradication of cold housing (raising indoor temp to ≥18°C)	HALYs gained (discounted, 3%): 89,600 (95% UI: 47,700–177,000) Health expenditure saved: AUD$871 million (2021–2040) Income gain: AUD$4.35 billion Greater benefits in most deprived groups (6.1x HALYs vs least deprived)	Eradicating cold housing would yield significant health, equity, and economic benefits. Respiratory and mental health effects contribute most. More research is needed on causality magnitude, but policy action should not be delayed given likely large benefits.
Svensson et al., 2018	Sweden	2012	Reducing indoor radon levels to 100 Bq/m³ (from 200 Bq/m³)	Existing homes: 925,053 SEK/QALY (healthcare), 1.22M SEK/QALY (societal) New homes: 103,534 SEK/QALY (healthcare), 366,672 SEK/QALY (societal) Cost-effective only for new homes at Swedish threshold (500,000 SEK/QALY)	Lowering radon levels to 100 Bq/m³ is cost-effective in new homes, but not in existing homes. Policy should focus on enforcing the current 200 Bq/m³ standard in the existing housing stock.

Uppal et al., 2021	Canada	2018	Social/behavioural risk reduction such as tobacco use, heavy drinking, food insecurity and overcrowding mitigation	Tobacco reduction ICER: $49,671/QALY Combined all strategies: ICER ~$13.9M/QALY Overcrowding reduction: high cost, minimal prevalence impact (0.49%)	Tobacco reduction is the most cost-effective TB prevention strategy. Overcrowding reduction is costly but has potential. Community-led approaches are essential for sustainable public health gains.
Guo et al., 2022	China	Not specified	Clean heating transition (multiple strategies including coal-to-gas, electricity, ISH, improved CH)	Improved CH strategy reduced PM2.5 emissions to 1/5th of baseline; health cases dropped from 63,148 to 8,134; Total net social benefit: 1796.95 million CNY – highest among all strategies. Some strategies caused net social losses in rural areas but delivered urban health gains.	A differentiated clean heating strategy that considers urban-rural variations maximizes social welfare. Improved CH is most cost-beneficial but requires careful policy design to address rural equity and heating poverty.
Irfan et al., 2021	Pakistan	Not specified	Interventions to reduce indoor air pollution (biogas, LPG, natural gas, electric stove, improved cookstove)	Cost benefit Ratios (BCRs): - LPG: 4.64–4.43 - Natural gas: 4.64–4.30 - Electric stove: 3.07–2.83 - Biogas: 2.67–2.41	LPG is the most cost-effective intervention for reducing indoor air pollution in Pakistan. Natural gas and electric stoves are also beneficial but face infrastructure constraints. ICS is not cost-effective due to limited health gains and continued use of

				- ICS: 0.38 (not cost-beneficial) NPVs (in PKR): LPG ~338–170 billion; Natural gas ~337–165 billion; Electric stove ~287–133 billion; ICS: Negative NPV	solid fuel. Findings support adoption of cleaner fuels.
Katona et al., 2005	Hungary	2002	Ventilation strategies to reduce radon concentration	Optimal ventilation rate: 0.22–0.66 h^{-1} depending on radon entry rate Optimal indoor radon concentration: 160–210 Bq/m^3 Periodic ventilation reduces inhalation dose by 30–70% vs. continuous ventilation for same cost	Ventilation can economically reduce radon exposure, especially with periodic strategies. Recommended action level: ~400 Bq/m^3 considering local heating cost and uncertainty. Periodic ventilation is more effective than continuous under same cost.

It's important to note that the studies identified span nearly two decades (2005-2023), meaning economic valuations and healthcare costs may not be directly comparable due to inflation and changes in healthcare systems over time. Several studies focused on radon mitigation (UK, Canada, Sweden), generally finding it cost-effective in new constructions and high-radon areas, with more recent analyses (Gaskin et al., 2019, 2020, 2021; Svensson et al., 2018) potentially reflecting more current economic conditions. Ventilation strategies (Katona et al., 2005 - Hungary) also show promise for radon reduction, though this is an older study.

Energy-efficient retrofits (UK, New Zealand) like insulation and efficient heating demonstrate cost-effectiveness, with a more recent study (Rodgers et al., 2018 - UK) providing contemporary evidence of reduced hospital admissions. Public-private reinvestment (Baird et al., 2020 - USA) offers insights into modern urban development challenges.

Interventions targeting indoor air pollution include HVAC filters (Aldred et al., 2015 - USA), personal protection against mosquitoes (Babu et al., 2007 - India), air cleaners (Chau et al., 2008 - Hong Kong), and clean heating transitions (Guo et al., 2022 - China; Irfan et al., 2021 - Pakistan). The more recent studies on clean heating reflect current concerns about air quality and climate change.

Addressing social/behavioural risks (Uppal et al., 2021 - Canada) offers contemporary perspectives on tuberculosis prevention. Home modifications for fall hazard reduction (Keall et al., 2017 - New Zealand) provide relatively recent cost-benefit data for an aging population.

Studies highlighting the burden of poor housing (Riggs et al., 2021 - New Zealand) and wood heater pollution (Robinson et al., 2021 - Australia) offer up-to-date assessments of these issues. The analysis of eradicating cold housing (Mishra et al., 2023 - Australia) is the most recent and reflects current priorities around health equity and energy poverty.

Overall, the studies indicate that policy efforts should focus on supporting and expanding retrofit and insulation programmes, particularly targeting elderly, low-income, and medically vulnerable populations. By prioritising interventions using geospatial health risk data, resources can be directed where they are most needed and likely to have the greatest impact. Furthermore, aligning housing improvements with public health objectives has the potential to deliver significant co-benefits, including reduced healthcare utilisation and improved wellbeing. Overall, while the varied dates of these studies provide a historical perspective, caution is needed when directly comparing absolute cost figures. More recent studies likely offer a more accurate reflection of current economic and healthcare landscapes. The consistency of findings across different time periods for certain interventions (e.g., radon mitigation in new builds) strengthens their generalisability.

3.2 Costing Analysis for Scotland – replicating BRE using Scottish survey data

3.2.1 Introduction

To assess the cost of poor housing due to its impact on health, the availability and coverage of data on housing and health is essential. In the UK, BRE Trust, a charity investing in research, calculated the poor housing cost for England, Wales and Northern Ireland linking each of the 26 or 29 hazards defined by the Housing Health and Safety Rating System (HHSRS, 2006) with information from their national house condition surveys. Within the BRE report analyses, hazards are related to the housing design and condition, and they exclude all risks from occupier behaviour (e.g., exposure to cigarette smoke, exposure to dust due to lack of cleaning etc.). Based on the risk extent, each hazard in every house is then categorised as category 1 or 2, where category 1 is the immediate risk to a person's health and safety, and 2 is any lower extent. According to HHSRS, any house assessed having a category 1 hazard can be classified as poor housing.

To assess the cost of poor housing, the method is to first identify key housing factors contributing to the hazard, linking them with the main health repercussion linked to the hazard and the extent of such link. Secondly, the costing exercise is twofold: firstly calculating the NHS cost to treat health conditions related to the housing hazard, then, calculating the 'mitigation' costs to clear the category 1 hazard.

BRE uses this approach, applying national housing conditions survey to identify key housing factors contributing to the hazard. Most of the hazards are surveyed and assessed directly by a surveyor inspecting the house, others are modelled based on survey data (collected by both the surveyor and self-reported by the house occupiers). The link between the housing factor and health repercussion is crucial to assess the health cost and it is based on the surveyor's assessment. The surveyor links the hazard to the health classifying the likelihood of the occurrence and the extent of the potential harm (measured in a class – weighting scale), based also on the characteristics of who lives in the house (e.g., some factors can be hazard for elder people may not be for young adults and vice versa).

While the surveyor inspection methodology for England, Wales and Northern Ireland for their House Condition Survey is the same, Scotland uses a different methodology for its Scottish House Condition Survey (SHCS), resulting in a shorter survey which is difficult to compare with the other nations and importantly it does not include many of the 29 hazards used in the BRE reports. Only 9 out of the 29 hazards are common between the SHCS and the other nations housing surveys. Table 5 below details the hazards from the English survey which relate to the SHCS questions and the extent of overlap. The differences in surveys/ hazards identified is also due to the varying classification of 'poor housing' in England and Wales compared to Scotland (see introduction). Indeed, the SHCS aligns with the Scottish Housing Quality Standard, which has broader categories to define housing standards compared to specific hazards. The SHCS reports on dwellings that are: energy efficient, safe, and secure; not seriously damaged; and in good condition regarding kitchens and bathrooms, without focusing on specific hazards. Only a few hazards (e.g., the presence of damp and mould) may overlap between the two classifications; however, the extent of a house risk to be classified as a 'category 1 hazard' or to fail the 'Scottish tolerable standard' may differ.

3.2.2 Methods

For the purposes of this study, and given the limited time, we adopted a preliminary approach to best replicate the BRE analyses, using the Scottish SHCS data for 2023.

The BRE methodology was to identify key housing factors contributing to the hazard, linking them with the main health repercussion of the hazard and the extent of such link; and then secondly, a costing exercise to (1) estimate the NHS system cost to treat the health repercussion related to the housing hazard, followed by (2) estimating a 'mitigation' costs to improve the category 1 hazard to a category 2 hazard. The BRE classification of mitigation cost - Where a category 1 HHSRS hazard is identified in the EHS, the surveyor report's the work that would be required to reduce the hazard to bring it up to the average for the age and type of dwelling.

To replicate this for Scotland we initially identified questions within the 2023 SHCS assessing a specific housing hazard. We then checked the weight of those hazards identified in the SHCS in the other BRE reports referring to England (Garret et al. 2021; report based on 2019 survey), Northern Ireland (BRE 2018 report on the 2016 survey) and Wales (Nicol 2019; report on the 2017-18 survey) out of the total NHS and mitigation costs. An explanatory step by step example is given in Appendix 3.

3.2.2.1 Linking SHCS questions to hazards:

We identified 9 hazards in the SHCS which can be related to or used as a proxy for the hazards used in the previous BRE reports. Only a few hazards were identified through single questions/fields to cross in the SHCS (i.e., the field '*Characteristic below tolerable standard: adequate supply of wholesome water'* was directly linked with the hazard '*Water supply'*). In contrast, other hazards were indirectly identified through broader questions (e.g., the question identified the hazard but, potentially, also additional dwellings beyond the definition of the hazard itself). For instance, the hazard '*excess of cold'*, can be identified from questions on the level of cold in the house; yet this could be due to energy poverty rather than structural housing conditions. In such cases we tried to remove those houses unable to be heated for reasons due to poverty and focus on those related to structural conditions. In these cases, sensitivity analyses were also undertaken, reducing the number of dwellings identified by such questions using a multiplicative factor between 0 and 1 (to identify 'excess of cold' for the base case analysis the number of dwellings identified through the survey was multiplied by .67 – see Table 5). In addition, in some instances there was not a perfect correspondence between questions and hazards, but questions could be used as a proxy for certain hazards adding some further uncertainty (i.e., '*Characteristics below tolerable standard: WC with exclusive use of the occupants of the house*' can be used as a proxy for the hazard '*Sanitation* (Personal hygiene)'). Such questions and the associated estimates were used in an additional scenario called 'extensive identification'. It is worth noting that the term 'extensive' only refers to a higher number of hazards identified within the SHCS but not on their extrapolation costs: higher number of questions identifying hazards may lead to fewer number of dwellings affected by such hazards in Scotland and then an overall lower cost compared to other nations. Table 5 lists all the hazards, with the related questions and assumptions included in the 'base-case' or 'extensive' alternative methods.

Table 5: List of hazards identified, SHCS question and source and corresponding assumptions

	Base-case identification		Extensive identification		Comments
List of Hazards	**SHCS question**	**Number responding**	**SHCS Question**	**number households responding**	
Excess cold	During the winter months, do you generally find that your heating keeps you warm enough at home? No, Never *Chapter 4 EP1*	140000	During the winter months, do you generally find that your heating keeps you warm enough at home? No, Never *Chapter 4 EP1*	140000	6% of households had stated that their heating never kept them warm enough. Yet 12% was the proportion of people mentioning affordability as one of the causes making it difficult to heat the house. As the questions belongs to two different subsections within chapter 4, this is based on the assumptions that affordability has the same distribution across people having different capacity and perception of staying warm at home during winter (Table EP1). Given the high estimates compared to other constituencies, in addition to this, a sensitivity analysis with 2/3 of this figure was applied.
Falls on stairs	-	-	-	-	
Falls on the same level – e.g. slips	-	-	-	-	
Hot surfaces	-	-	-	-	
Falls between levels*	-	-	-	-	
Fire	-	-	-	-	
Lead	-	-	-	-	
Radon	-	-	-	-	
Damp and mould growth	Below tolerable standards dwelling: free from rising/penetrating damp *Chapter 5 HC10*	15000	Dwelling with presence of rising or penetrating damp. *Chapter 5 HC7*	15000	
Collision and entrapment	-	-	-	-	
Food safety	-	-	-	-	
Pests (Domestic hygiene)	-	-	-	-	
Entry by intruders	-	-	Disrepair to external critical elements, external doors *Chapter 5, Table HC6*	5750	As critical disrepair to external doors is not directly affecting entry by intruders, as other features are also relevant (e.g., dwelling type, location and specific housing features), 5% of this figure was used, which was also based on weighted comparison with Wales and England reporting this hazard. A sensitivity analysis with 1/2 of this figure was applied.

	Base-case identification	Extensive identification	Comments		Base-case identification
List of Hazards	**SHCS question**	**Number responding**	**SHCS Question**	**number households responding**	
Ergonomics	-	-	-	-	
Sanitation (Personal hygiene)	-	-	Below tolerable standard dwelling: WC with exclusive use of the occupants of the house, Chapter 5, HC10	3000	
Structural collapse	Below tolerable standard dwelling: structurally stable dwelling, Chapter 5, HC10	2000	Below tolerable standard dwelling: structurally stable dwelling, Chapter 5, HC10	2000	
Carbon monoxide	-	-	-	-	
Noise	-	-	-	-	
Overcrowding	Percentage of dwelling which are below the bedroom standard Chapter 6 BS1	61000	Percentage of dwelling which are below the bedroom standard Chapter 6 BS1	61000	
Excess heat	-	-	-	-	
Electrical problems	Below tolerable standard dwelling: safe electrical system, Chapter 5, HC10	3000	Below tolerable standard dwelling: safe electrical system, Chapter 5, HC10	3000	
Falls - baths	-	-	-	-	
Water supply	Below tolerable standard dwelling: satisfactory supply of hot and cold water within the house, Chapter 5, HC10	1000	Below tolerable standard dwelling: satisfactory supply of hot and cold water within the house, Chapter 5, HC10	1000	
Uncombusted fuel gas	-	-	-	-	
Lighting	Below tolerable standard dwelling: Satisfactory provision for lighting, ventilation and heating Chapter 5, HC10	250		250	This element was recorded but as the number of dwellings experiencing such element failure was too low to be reported, and figures are rounded to the closest 1,000, the median number between 0 and 499 was chosen.
Explosions	-	-	-	-	
asbestos	-	-	-	-	
biocides	-	-	-	-	
volatile organic compounds	-	-	-	-	

*This is hazard refers to falls from a height from one floor or level to another, such as falls from windows, balconies, or an open edge (e.g., a hole in the floor). It is distinct from a fall *on* a staircase.

After adjusting the costs of poor housing for England, Wales and Northern Ireland to 2024 cost year, using average yearly inflation (Bank of England, 2025[4]), we identified the average costs per dwelling for the 9 identifiable hazards in the BRE reports, as reported in the results section- Table 6.

3.2.2.2 Challenges in comparing across nations

Overall, the adjusted specific cost of the Scottish identified hazards was significantly different across the three nations. For instance, the average cost per dwelling with 'Damp and mould' adjusted by inflation was £27,040 in Northern Ireland, while it was £4,403 and £6,004 in England and Wales, respectively (Table 6). These differences could be due to the average different extent of the hazards, different age of the dwellings as well as different location (rural vs urban) (Piddington, et al. 2020). For specific categories of hazards, such as 'excess of cold', the BRE report for England used a different methodology to estimate the mitigation costs. Therefore, to consider for these and other differences across nations, every Scottish individual hazard cost was computed following the different nations' report estimates, producing results for three different scenarios. There are also wider differences across data collection systems which increase the challenges of comparing across each of the different surveys: Scotland and Wales do not inspect vacant dwellings whereas England and Northern Ireland do. Furthermore, England and Wales did not model specific hazard dimensions (e.g., lighting and water supply) that were modelled into the Northern Ireland report, therefore these cost estimates were only included in scenarios that incorporated Northern Ireland data. Comparing the housing stock characteristics across nations (age, type, location and tenure), England seems the most similar to Scotland. This shows how the comparison of Scotland data could better match a nation for similarity of specific housing stock characteristics but another nation for data collection methods or other features.

3.2.2.3 Scottish Cost estimation – method applied

Given this uncertainty in the underlying data and assumptions, linking SHCS questions to hazards, in the attempt to estimate the Scottish cost of poor housing, a base-case 'conservative' estimate was produced, as well as an alternative 'extensive' cost to explore what the cost would have been had an alternative question (proxy from SHCS) been used to identify the hazards. Table 6 and 7 reports the results for the base-case conservative approach and the alternative extensive approach, using the cost and weighting from each of the three different countries, and with the average from across them all.

It is worth noting that economies of scope play a role, and the cost associated to mitigate multiple hazards for the same dwelling may be lower than the sum of the cost of the hazards, and the BRE reports take this into account. Similarly, economies of scale can come into play. Programmes regarding extensive areas and multiple properties may incur lower costs compared to the sum of the single costs.

The SHCS only enabled linking to 9 hazards out of the 26 reported in BRE. To estimate the likely cost of the additional hazards for Scotland (and enable comparison on total costs from

[4] Cost year for analysis was 2024, using the inflation indices published by Bank of England in 2025. This is the date of the reference.

Scotland with the three BRE reports) we first calculated the weight of the 9 identified hazards in England across the full 26 hazards: 0.66. This weighting figure was then used to project the figure for a total cost in Scotland (multiplying the weight to the cost for Scotland of the 9 hazards alone). This gave an estimated cost for Scotland across all 26 hazards (see Results Table 7). See Appendix 3 for a step-by-step breakdown of the approach. This approach is helpful, as it enables us to predict a cost for Scotland comparable to the other BRE reports, and makes best use of the limited data we have, however, there remains high uncertainty, and using alternative weights (based on the Wesh or Norther Irish proportion) results in highly variable cost estimates.

Most of the identified hazards in the SHCS come from Chapter 5 in the section on dwellings below tolerable standards. Being below a tolerable standard means that it is not reasonable to expect people to continue to live in a house that falls below it. In the SHCS all figures regarding estimates for the number of dwellings are rounded to the closest thousand.

3.2.3 Results

Table 6 presents the NHS cost and individual mitigation cost estimates for each of the 9 identified hazard, across the 3 nations in the BRE reports.

Table 6. NHS costs and cost of mitigation by hazard for each nation, for the 9 hazards in Scottish Housing Condition Survey

		Cost of individual hazards in different nations (weights out of total cost)													
Nation	Type of cost	Excess cold	Damp and mould growth	Domestic hygiene, pests and refuse *	Electrical hazards	Lighting	Entry by intruders*	Water supply for domestic purposes	Structural collapse and falling elements	Crowding and space	total n. of dwelling with such hazards	proportion of n. of identifiable hazards in SHCS in other Nations' report	proportion of costs of identifiable hazards in SHCS in other Nations' report	proportion of n. of identifiable hazards in SHCS in other Nations' report*	proportion of costs of identifiable hazards in SHCS in other Nations' report*
England	Mitigate	£ 8,732	£ 4,403	£ 911	£ 2,790	-	£ 1,376	-	£ 781	£ 25,220	964,522	0.37	0.71	0.39	0.71
	NHS	£ 1,258	£ 628	£ 255	£ 257	-	£ 599	-	£ 190	£ 165			0.66		0.67
NI	mitigate	£ 5,448	£ 27,040	£ 5,351	£ 5,055	£ 5,126	£ 1,349	£ 1,391	£ 8,563	-	25,606	0.37	0.39	0.55	0.45
	NHS	£ 932	£ 292	£ 214	£ 134	£ 115	£ 279	£ 124	£ 86	-			0.41		0.47
Wales	mitigate	£ 4,473	£ 6,004	£ 2,995	£ 2,462	-	£ 1,570	-	£ 3,146	£ 24,689	72,492	0.32	0.48	0.33	0.48
	NHS	£ 895	£ 358	£ 270	£ 164	-	£ 342	-	£ 106	£ 118			0.48		0.48
average all	mitigate	£ 6,218	£ 12,483	£ 3,086	£ 3,436	£ 5,126	£ 1,432	£ 1,391	£ 4,164	£ 24,954					
	NHS	£ 1,028	£ 426	£ 246	£ 185	£ 38	£ 407	£ 41	£ 127	£ 94					

*= values referring only into the extensive identification of hazards.

NHS cost is the annual NHS cost associated with treating health condition related to the specific hazard. Cost of mitigation is the estimated one-off cost needed to rectify category 1 hazards to improve them to make them acceptable by Health and Safety Rating System (HHSRS) standards (category 2).

The total sum of all dwellings with category 1 hazards in each report is lower than the sum of the individual hazards as some dwellings will have more than one category 1 hazard. Similarly, cost to mitigate all Category 1 hazards is lower than the total number of hazards multiplied by the average costs; as economies of scope comes into play whenever work/energy improvements mitigate more than one hazard.

As detailed in Table 6, using the base-case (conservative identification of hazards), the proportion of identifiable hazards within the SHCS is similar across constituencies (32-37%) (Table 6). Conversely, the extensive identification scenario showed a closer similarity between England and Wales (39% and 33%, respectively), while Northern Ireland exhibited a significantly higher proportion (55%). The observed discrepancies between reports suggest that the conservative identification method provides greater consistency across constituencies, and thus, may be more reliable. For that reason, we report the 'conservative method' as the baseline results. In terms of which country is most similar to Scotland, regarding housing age, type and tenure, England is best aligned, and we therefore propose that using the NHS England costs and weights with the conservative approach should be the base-case analysis for Scotland.

Costs were categorized as cost of mitigation[5] and annual cost to NHS for treating health conditions associated to the identified hazards. Unitary costs differ more regarding mitigation rather than cost to the NHS as local and distribution expenses may vary by nations. Regarding mitigation costs, the highest cost individual hazard to mitigate was overcrowding (over £20,000 in all nations), followed by excess of cold (being £8,732 -the highest- and £4,473 -the lowest- in England and Wales, respectively). While the individual cost is relevant, the overall cost burden is determined by the prevalence of hazards across dwellings. Consequently, excess cold being more common as a category 1 hazard represents the most significant cost burden across all nations for both cost to the NHS and cost of mitigating hazards, as shown in Appendix 3, Table A3.1 and A3.2. However, when costs associated with all fall related hazards are combined, falls become the most common and second costliest hazard regarding mitigation and the NHS.

Table 7 presents the results in terms of costs to the NHS for treating health conditions related to the hazards, and the costs to mitigate the hazards, using the base-case conservative approach, and the alternative extensive approach, using the alternative weighting from each of the 3 BRE nation reports.

The NHS costs are the annual cost to the Scottish NHS based on the household data from the SHCS for the 9 specific hazards where there were data and using the other nations data (adjusted for Scotland) for the other 17 hazards. The estimated cost to the NHS ranges from £433 million (based on the conservative estimation method) to £674 million (based on the extensive estimation). Given the differences in hazard incidence and variability in healthcare systems between England, Northern Ireland, Wales and Scotland, averaging NHS costs across constituencies may provide a reliable estimate of £526million per annum. However, we propose England as the best proxy for Scottish housing stock characteristics and report's methodology, assuming this and the conservative approach for a base-case, we estimate the annual NHS cost of poor-quality housing in Scotland to be £530million.

[5] Cost of mitigation is the estimated one-off cost needed to rectify the existing category 1 hazards to improve them to make them acceptable by Health and Safety Rating System (HHSRS) standards, e.g. so they could then be classed as a category 2 which is the minimal acceptable standard.

Regarding costs to mitigate, this represents a one-off upfront investment cost required to improve all the households to move them from a category 1 to category 2 level hazard. The one-off cost to mitigate the hazards are higher than the annual cost to the NHS for treating health conditions associated with such hazards, however, if these hazards were mitigated, there would be annual NHS cost savings through avoiding the health related conditions once the hazard is resolved. In the BRE England report a pay-off period of 7-8 years is stated from an NHS perspective, i.e. within 7-8 years the cost savings to the NHS of avoiding treating health conditions related to the hazards would outweigh the upfront cost of resolving the hazards. If a societal perspective is taken -which would account for additional benefits to society – then the pay-back/breakeven point on the cost of mitigations is only 1 year (Table 3).

Regarding the alternative methods used to calculate the cost of mitigating hazards, there is high variability between national estimates, so using the average across the nations is unlikely to be reflective of the true cost for Scotland. Considering which nation best reflects Scotland is crucial for inferring the Scottish cost. An example of a reliable method could consist in identifying the specific housing stock features (e.g., average age, location, type etc.) that can be associated with a higher exposure to specific hazards. Subsequently, based on how much the Scottish housing stock match the stock of the other nations (e.g., in a propensity score fashion), an explicit cost per hazard can be estimated by the weighted contribution of each feature to the hazard based on the national costs. However, this is only a potential method of many available without changing the current Scottish Household Condition Survey. Nevertheless, current detailed information on the housing stock features and their relationships with each hazard were not available. Therefore, we are limited to report overall mitigation costs in Table 7 based on the three different reference nations.

We propose England as the best proxy for Scottish housing stock characteristics and report's methodology, assuming this and the conservative approach for a base-case, the cost to mitigate hazards could be between £7.7 and £8.7bn. These estimates are highly variable under alternative approaches ranging between £17.4-18.6bn and £11.6-13.2bn if using methods and reports from Northern Ireland and Wales, respectively.

Table 7. Estimated total NHS cost and cost to mitigate category 1 hazards for Scotland (based on extrapolations from other nations' reports).

Nation	Type of cost	Base-case Estimate for Scotland*		Sensitivity Analysis on 'excess of cold' and 'entry by intruders' Estimate for Scotland	
		Conservative identification	Extensive identification	Conservative	Extensive identification
England	Mitigate***	£ 8,272,936,275	£ 8,685,934,304	£7,698,608,331	£7,849,326,343
	NHS**	£ 529,568,090	£ 701,874,829	£440,668,870	£497,443,635
NI	Mitigate	£ 18,674,068,572	£ 18,357,821,932	£18,029,615,128	£17,387,074,958
	NHS	£ 620,939,108	£ 648,649,347	£463,618,441	£474,556,317
Wales	Mitigate	£ 12,011,540,628	£ 13,272,100,820	£11,572,296,330	£12,385,369,874
	NHS	£ 482,920,813	£ 659,479,906	£395,118,333	£474,129,253
average all	Mitigate	£ 15,363,877,635	£ 15,919,698,853	£14,812,681,057	£15,031,574,316
	NHS	£ 525,683,937	£ 673,874,543	£432,823,145	£481,338,275

*The cost estimates in this table are the total costs estimated cost for Scotland across all 26 hazards. **NHS cost is the annual NHS cost associated with treating health condition related to the specific hazard. ***Cost of mitigation is the estimated one-off cost needed to rectify category 1 hazards to improve them to make them acceptable by Health and Safety Rating System (HHSRS) standards (category 2).

Table 8 summarises the results for the Scottish estimates of cost to the NHS compared to the BRE cost analysis results for each country (as reported in Table 3). The costs estimated for Scotland are for cost year 2024 using (i) the conservative approach - as a base-case - and (ii) using the conservative sensitivity analysis. The latter approach utilised a fewer number of hazards in Scotland which in certain fields seem too high, hence why the cost of £440million is a lower estimate than the base-case. We estimate the annual cost to the NHS for poor-quality housing via home hazards to be £530million per annum, ranging between £433mil - £674mil per annum depending on the alternative approaches used as detailed in Tables 7 and 8.

Table 8: BRE report summary annual NHS costs with Scottish equivalent added

BRE Cost Analysis Findings	BRE England Garrett, et al 2021	BRE Wales Nicol et al. 2018	BRE Northern Ireland Nicol et al. 2019
BRE Cost to NHS (£/year)	£1.4 billion	£95 million	£40 million
BRE Cost to NHS per annum Inflated to price year 2024	£1.68 billion	£121million	£52 million
Scottish equivalent* cost using conservative approach	£529.5million	£ 482.9million	£621million
Scottish equivalent* cost using conservative sensitivity analysis (reduced hazards) approach	£440million	£395million	£463million

*Scottish equivalent calculated for price year 2024, estimated for 26 hazards

3.2.4 Limitations of the analysis

The primary limitation of this analysis is the reliance on secondary data not originally collected for costing purposes. Indeed, the SHCS aims to monitor the physical condition of Scotland's housing stock along with the experiences of householders, but without having cost of hazards (or any other classification of risk) among the explicit objectives. Consequently, the scope of relevant survey questions and surveyor assessments was limited, with only 9 out of 26 identified HHSRS hazards being directly discernible from the available data. Furthermore, certain significant hazards, such as 'excess cold,' required inference from multiple survey questions, thereby increasing the overall uncertainty of the cost estimates. Additionally, Scotland's distinct housing characteristics compared to other UK nations may render direct comparisons inappropriate. This is particularly evident when significant cost variations exist between nations (especially for mitigation cost). For instance, the average individual cost of 'damp and mould' or 'structural collapse' were substantially different between nations, this could be due to different housing stock characteristics, but also to different methodologies or assumptions in the various nations BRE reports, as seen with 'excess cold' in England. Fortunately, the observed variations in NHS impact and cost are relatively minor (see Appendix 3, Table A3.2); therefore, the primary concerns remain focused on the estimation of mitigation costs.

Overall, the analysis provides potentially indicative, albeit imprecise, estimates for Scottish NHS costs. However, significant challenges in comparing mitigation cost estimates across BRE reports were encountered. These challenges stem from variations in hazard weighting, potentially attributable to differing survey representativeness, diverse hazard assessment methodologies, and variable repair costs. Furthermore, the absence of detailed housing stock characteristics to facilitate optimal comparator selection across UK nations has resulted in potentially inaccurate and biased mitigation cost valuations.

Additionally, the SHCS data were rounded to the nearest 1,000, which introduces further uncertainty. Obtaining raw, unrounded data would require a lead time of several months, exceeding the project's current timeline.

3.2.5 Recommendations for improvements

- Access to raw SHCS data: Having access to raw data for SHCS would significantly improve the precision of estimates by eliminating rounding-related uncertainty. However, this strategy alone may result in spurious precision due to the inherent structural bias arising from the limited number of hazards detectable within the SHCS. Obtaining raw, unrounded data would require a lead time of several months, and may incur financial expense depending on the nature and time required to access and obtain specific variables.

- Reshaping Future Surveys covering other relevant hazards: when considering all fall-related hazards, falls emerge as a major mitigation cost contributor in Northern Ireland and Wales (0.28 and 0.42, respectively). In England aggregated falls were the second hazard in terms of costs, potentially due to a different methodology to assess ‘excess of cold’. Similarly, the Long & Cullum 2024 review highlighted falls as a key driver of health impact (which is also monetizable in terms of NHS related costs) from poor-quality housing. The inability to infer fall-related hazards from the SHCS represents a significant data gap, contributing to the imprecision of our overall cost estimates. Future assessments that quantify category 1 hazards associated with falls in Scotland would substantially improve the accuracy of cost estimations related to poor housing conditions.

- Establishing a discussion with BRE: to understand the main strategies and methods to implement a coherent cost of poor housing in Scotland. Given the current data a conversation with BRE specialists/analysts who developed other nations reports may be useful to improve current estimates, suggest what could be done to improve quality of data from the survey and how to plan a future pilot survey.

- Designing a pilot survey with greater coverage of housing hazards to inform better policy directions as well as develop methods is an opportunity to produce more accurate estimates.

3.2.6 Summary of Cost Analysis Results

This preliminary cost analysis has estimated that (if using England as the best comparator and report's methodology), and the conservative approach, the cost to the NHS of poor-quality housing in Scotland is likely to be £530 million per annum. The one-off cost required to mitigate these hazards associated with poor-quality housing is estimated to be between £7.7 and £8.7bn. The NHS costs are the annual cost to the NHS of treating health conditions related to the housing hazards, based on the household data from the SHCS 2023. The mitigation cost represents a one-off investment (by the housing sector or government) to improve those households hazards to move them from a category 1 to category 2 level hazard. The beneficial health impacts of undertaking these improvements will remain for many years, incurring NHS savings (avoiding the estimated NHS cost of £530million per annum) so a longer timeframe and full economic analysis could better represent the monetary benefits for the NHS – and wider society - of mitigating the hazards.

4. Informing future study directions

The aim of this section is to address Research Question 1.3.3 as outlined in the study scope: to reflect on the findings from the literature reviews, cost consequences and cost analysis regarding the strength of the existing evidence base and areas of uncertainty. Options for potential future work have been suggested including the potential methodologies and potential study requirements and scale should further research be needed.

4.1 Strength of the evidence base

Key findings from The Long & Cullum 2024 evidence review on outcomes indicate evidence linking poor housing hazards—specifically cold temperatures, damp and mould, and overcrowding—to significant health issues including respiratory conditions, cardiovascular disease, and infectious diseases. Interventions addressing warmth, energy efficiency, and environmental hazards show clear improvements in health outcomes, reduced hospital visits, and lower rates of falls among older adults. There is a reasonably strong evidence base that interventions which address these areas can improve health and societal outcomes. In terms of evidence on retrofitting, as detailed in Table 2, there was some UK specific evidence which indicated that warmth and energy efficiency measures such as the installation and upgrading of central heating; the installation of insulation (roof, cavity wall, or both); and the installation of double glazing; improves the general health, asthma symptoms and respiratory health of adults and children. .

Economic evidence is needed to assess whether investment in housing improvement provides value for money and which interventions to invest in. The economic evidence review identified substantial gaps in existing data, particularly within the Scottish and UK context, highlighting a scarcity of comprehensive economic evaluations on housing quality improvements. The limited available data mostly focussed on radon reduction efforts, and while they were shown to be mostly cost-effective, these types of interventions are not directly relevant to evidencing a case for investment in housing quality improvement. As detailed in Table 4, three UK specific studies showed that energy efficient retrofits to home boilers and windows reduce exposure to indoor air pollution in dwellings and council housing upgrades resulted in health improvements and cost savings (Bray, et al. 2017; Drymond, et al. 2021; Rodgers, et al. 2018). Evidence from the review overall does consistently suggest economic benefits from targeted housing interventions, particularly those improving energy efficiency and reducing domestic hazards such as falls. While there is underlying uncertainty and data quality issues in the economic studies and the results presented, all the studies did show potential for cost saving or cost-effectiveness and that investments in such endeavours are worthwhile/ a good use of finances to improve public health.

4.2 Options to strengthen the economic case for investment in Scotland

The Cost analysis in Section 3.2 is a useful first step to develop a Scottish based value case for investing in good quality housing replicating the BRE methodology with the existing equivalent data in Scotland. The study estimated that the likely costs to the NHS of poor-quality housing in Scotland costs the NHS £530million per annum. Overall, the analysis provides potentially indicative, albeit imprecise, estimates for Scottish NHS costs. However, significant challenges in comparing mitigation cost estimates across BRE reports were encountered. There are many limitations in the underlying data, assumption and alternative methods which could be used.

4.2.1 Options for future studies

- As detailed in section 3.2.5 the preliminary cost analysis could be replicated and updated using more reliable/ robust raw SHCS data. Having access to raw data for SHCS would significantly improve the precision of estimates by eliminating rounding-related uncertainty and would enable further sensitivity analyses. We already have the contacts at SHCS who can support gaining access to this data, and while accessing this would require a lead time of several months, this is achievable and most likely to be a financially inexpensive option.

- Feeding into the design and roll out of the next SHCS survey to ensure additional data fields are captured to address the gaps in the Scottish data, e.g. including questions / data fields regarding falls to enable a better matched analysis with the BRE reports. The inability to infer fall-related hazards from the SHCS dataset represents a significant data gap, contributing to the imprecision of the preliminary estimates in section 2.2.

- It is unlikely that a discrete choice experiment (DCE) study to determine peoples 'willingness to pay' for improvements in housing quality would add much value to the evidence gap. This study method could be employed to elicit monetary values for a CBA, but it is unlikely to be necessary. While no DCE studies in this area were identified in the economic review, the CBAs that have been undertaken have used outcomes which are readily/ relatively easily monetised and the current approaches have sufficed in generating reasonably robust CBA results.

- A future CBA or other economic evaluation could help strengthen the evidence base for a Scottish context analysis, but would need to assess specific 'housing quality improvement strategies' that are relevant to Scotland and that Scottish policy or housing decision makers would be interested in investing in. For example comparing alternative retrofitting programs/interventions, or a wider comparison between investing in new homes versus retrofitting. Wider policy drivers including climate and environmental policy could also be considered. This could help direct specific investment activities to ensure the best value for money is achieved while incorporating climate and environmental targets. From the current evidence base there is outcomes and economic evidence to support retrofitting which addresses energy efficiency, warmth and reducing dampness. Likewise a decision analytic modelling could be undertaken to model alternative specific investment/ improvement strategies, but this again would need to be informed by government/ policy stakeholders as to the options they would be interested in. The Long & Cullum 2024 evidence review has highlighted that there is strong evidence that warmth and energy efficiency interventions (e.g. the installation, upgrading, or reparation of central heating; the installation of insulation (roof, cavity wall, or both); the installation of double glazing; or a combination of these) improves the general health, asthma symptoms and respiratory health of adults and children. Damp and mould type improvements also had a strong evidence base.   A modelling based economic analysis using a CBA and CUA could be undertaken to look at the specific cost-effectiveness of specific interventions in a Scottish context, but estimates on cost data for such interventions would be needed.

- If long term observational datasets are available and able to be linked a real world (before/after) evaluation of specific interventions, this could be undertaken based on previous UK or Scottish actual investments in housing.

- Similarly careful planning could enable prospective cohort dataset collection to enable a future CCA or CBA assessing the benefit to the health and the NHS of homes being built today and potentially in the not too distant future to the Scottish minimum standards of energy efficiency (Heat In Buildings 2028 standard). This would require access to current datasets (before) and data collection prospectively to enable comparison. Investments in new housing stock, or improving existing poor housing could also contribute to achieving Net Zero ambitions and climate resilience. None of the other UK BRE reports (Garret, et al. 2021; Nicol, et al. 2018; Nicol et al. 2019) have quantified these additional environmental gains in calculating the value of investing in good quality housing. One of Scottish Governments four key priorities is tackling the climate emergency and therefore such considerations could be built into a future study.

- Qualitative/ stakeholder engagement work could be undertaken to incorporate people's perspectives (and persons with lived experience of poor-quality housing) and what they think, which would strengthen the case for investment.

4.2.2 Stakeholder Workshop

Important questions remain regarding (i) has a value case for investment been made? (ii) what additional analyses are needed to strengthen the case. A stakeholder workshop was held in June 2025 with stakeholders from relevant government, policy, council, Housing Association, public health and academia to report on the results of this study and gain views as to what they think regarding the best way to demonstrate the effects that housing has on health as part of a political funding case for investing in good quality housing. A summary of this event has been added as an addendum to this report.

5. Conclusion

This study underlines the necessity of targeted housing improvements as a crucial element of preventative health policy and provides a foundational basis for advocating for further investment and research into the economic and health impacts of housing quality in Scotland.

From the outcomes evidence reviews, housing quality impacts on various aspects of physical and mental health, with variability in the strength and quality of the evidence base. The key factors which affect health outcomes were found to be cold indoor temperatures (affecting cardiovascular and respiratory conditions), damp and mould (affecting asthma, and other respiratory conditions) and overcrowding which had an impact on risk of infectious diseases.

With respect to evidence on specific interventions or housing improvements, the strongest evidence related to interventions which tackle warmth and energy efficiency in housing, address hazards which can result in fewer falls, and tackling damp and mould which can improve asthma symptoms. In terms of the strength of the evidence, there was a wide range of certainty on the evidence base (due to variability in study quality), however there was stronger evidence that interventions/approaches to reduce dampness, eliminate mould, improve warmth and energy efficiency, and removing environmental hazards can improve several physical health outcomes, including respiratory health, general physical health, and fall rates. The relationship between poor physical housing conditions and mental health was less clearly evidenced in the studies, however it was indicated that overcrowding can also impact on poorer mental health.

The evidence from the review shows that there is a need for more robust datasets and analyses to evidence causal links and strengthen the evidence base. There is high variability in the quality of the studies which impacts on their ability to evidence a causal link and on the certainty of the evidence base.

The economic evidence reviews showed that most studies undertook cost-consequence analyses or cost-effectiveness analyses, and most interventions were either found to be cost-effective or cost saving, despite some substantial investment required. None of the studies considered unintended consequences or health harms resulting from the interventions evaluated. UK specific studies showed that energy efficient retrofits to home boilers and windows reduce exposure to indoor air pollution, and that council housing upgrades resulted in health improvements and cost savings. Evidence from the review overall consistently suggest economic benefits from targeted housing interventions, particularly those improving energy efficiency and reducing domestic hazards such as falls.

The economic evidence indicated that policy efforts should focus on supporting and expanding retrofit and insulation programmes particularly targeting elderly, low-income, and medically vulnerable populations. However, the key drivers for this type of changes will more likely be climate change policy rather than housing policy. Furthermore, aligning housing improvements with government objectives on public health, environment, and inequalities, as per Scotland's new Population Health Framework (Scottish Government, 2025) is needed to demonstrate the potential to deliver significant co-benefits, including reduced healthcare utilisation, improved wellbeing, and reduced inequalities. Given the current restricted fiscal context and that there are many competing sectors in need of the limited public finances; quantifying a value case that incorporates the potential savings across areas by delivering multiple outcomes for health, social, environmental and economic benefit; will enable a stronger economic case for action to be taken to invest.

The cost analysis was a useful first step to develop a Scottish based value case for investing in good quality housing replicating the BRE methodology with the existing equivalent data in Scotland. The study estimated that the likely costs to the NHS of poor-quality housing in Scotland costs the NHS £530million per annum. Overall, the analysis provides indicative estimates for Scottish NHS costs of health conditions related to the housing hazards, however it is subject to uncertainty. There were limitations in the underlying data for Scotland and uncertainty in the methodological assumptions applied, as well as significant challenges in comparing mitigation cost estimates across the BRE reports. There are limitations in the underlying data, assumptions and alternative methods which could be used.

The evidence suggests that there is a positive case for investment in good quality housing in Scotland, and that such efforts will have beneficial health impacts and cost savings for the NHS, e.g., through avoiding annual cost of treating health conditions related to the housing hazards. However, we need more precise data, and better quality evidence to inform which Scottish housing specific interventions are of relevance and to properly estimate the costs and benefits in the Scottish context, to inform what investments/interventions will deliver the best value for money.

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7. Contribution Statements

Kathleen Boyd: funding acquisition, study conceptualisation, methodology design, analysis (evidence reviews) and interpretation of results, writing – original draft of report, writing – review and editing.

Ken Gibb: funding acquisition, study conceptualisation, methodology design, interpretation of results, writing – review of report.

Gareth James: study conceptualisation, writing – review of report.

Nishant Jaiswal: analysis (evidence reviews) and interpretation of results, writing – original draft of report, writing – review and editing.

Francesco Manca: analysis (evidence reviews, cost analysis) and interpretation of results, writing – original draft of report, writing – review and editing.

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9. Glossary

Category 1 hazard: a hazard that is a serious and immediate risk to a person's health and safety. Hazards are not only present hazards but also, they can represent the greatest potential for harm. They are defined by HHSRS and applies to residential properties in England and Wales. According to HHSRS, any house assessed having a category 1 hazard can be classified as poor housing.

Cost-Benefit analysis: A systematic process for evaluating the benefits and costs of an intervention, expressed in monetary terms to determine net value.

Cost-consequence analysis: An analysis that lists all the costs and all the relevant consequences (both positive and negative, not necessarily monetary) of different options, allowing for a broader comparison

Cost-effectiveness analysis: the most common type of economic evaluation which compare costs and outcomes measured in 'natural units', such as life years gained, cancers detected

Cost-utility analysis: A type of economic evaluation that measures the health outcomes of interventions in terms of quality-adjusted life years (QALYs) or other utility measures, alongside the associated costs.

Mitigation (cost): referring to the cost to mitigate category 1 hazards. It is the estimated one-off cost needed to rectify the existing category 1 hazards to improve them to make them acceptable by Health and Safety Rating System (HHSRS) standards, e.g. so they would no longer be classed as a category 1 hazard, but as a category 2 hazard. It is the cost of the necessary structural and internal adjustments required to address the hazards and improve them to a minimum acceptable standard.

Return on Investment: A performance measure used to evaluate the efficiency or profitability of an investment, it is calculated as the net profit or benefit divided by the initial cost or investment

Tolerable standard: threshold defined by the SHQS considering not reasonable to expect people to live in a house that does not meet this standard

10. References

- Baker, E., & Bentley, R. (2023). Housing and health: a time for action. *International Journal of Housing Policy*, *23*(2), 197–200. https://doi.org/10.1080/19491247.2023.2204650

- Bank of England, *Inflation Calculator*. https://www.bankofengland.co.uk/monetary-policy/inflation/inflation-calculator cited February 2025.

- Boyle, S and Husbands, J (2020) A New Case for Social Housing, Shelter Scotland et.al.: Edinburgh. Publication forthcoming. See https://scotland.shelter.org.uk/professional_resources/policy_library
- Congreve, E (2024) Housing in England and Scotland: Comparing Scottish data with English analysis by the Resolution Foundation. The Scottish Health Equity Research Unit (SHERU)
- Davidson, M., Nicol, S., Roys, M., Garrett, H., Beaumont, A., & Turner, C. 2012, Cost of poor housing in Northern Ireland. BRE Report. https://www.nihe.gov.uk/getattachment/542b5f8b-ac39-42ab-ad36-9b864473e3aa/cost-of-poor-housing-in-northern-ireland-in-2009.pdf

- DiTosto, J., Holder, K., Beestrum, M., & Yee, L. A systematic review of housing instability and adverse pregnancy outcomes. PROSPERO 2020 CRD42020219945 Available from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42020219945

- Donkin, A., Marmot, M., Friends of the Earth; '*Left out in the Cold: the Hidden impact of Cold Homes'* Institute of Health Equity, February 2024. Available online at: https://www.instituteofhealthequity.org/resources-reports/left-out-in-the-cold-the-hidden-impact-of-cold-homes
- Drummond M., Sculpher, M., Claxton, K., Stoddart, W., & Torrance G. *Methods for the economic evaluation of health care programmes*. Oxford: Oxford University Press, 2015
- Fenwick E, Macdonald C, Thomson H. Economic analysis of the health impacts of housing improvement studies: a systematic review. J Epidemiol Community Health. 2013 Oct;67(10):835-45. doi: 10.1136/jech-2012-202124. Epub 2013 Aug 8.
- Frey, J, Gibb, K, Harrington, N, James, G and Waite, D (2024, in press) Govan Local Housing Market Analysis. CacHE: Glasgow.

- Garret H., M.M., Nicol S., Piddington J., Roys M., (2021) *The cost of poor housing in England. 2021 briefing paper,* BRE Trust, Editor. 2021. Available online at: https://files.bregroup.com/research/BRE_Report_the_cost_of_poor_housing_2021.pdf

- Garrett,H., Mackay, M., Margoles, S. & Nicol, S. (2012) The cost of ignoring poor housing BRE Group – The Cost of Poor Housing to the NHS (1) The cost of poor housing to the NHS - BRE Group (2) BRE_the_Cost_of_ignoring_Poor_Housing_Report_Web.pdf (bregroup.com)

- Gibb, K, Leishman, C, Marsh, A, Meen, G, Ong Viforj, R and Watkins, C (editors) (2024) International Handbook of Housing Economics. Routledge: London.
- Gibb, K, Lawson, L, Williams, J and McLaughlin, M (2020) The Impact of Social Housing: Economic, Social, Health and Wellbeing. SFHA: Glasgow

- Guyatt, G., et al. (2011). GRADE guidelines: 1. Introduction - GRADE evidence profiles and summary of findings tables. *Journal of Clinical Epidemiology*, *64*(4), 383–394. https://doi.org/10.1016/j.jclinepi.2010.04.026

- HHSR, *Housing Health and Safety Rating System*. 2006: London. Office of the Deputy Prime Minister

- Higney, A, and Gibb, K (2024) Net zero retrofit of older tenement housing – The contribution of cost benefit analysis to wider evaluation of a demonstration project, Energy Policy, Vol.191

- International prospective register of systematic reviews, PROSPERO, NIHR. Available online at: https://www.crd.york.ac.uk/prospero/

- Long, H. & Cullum, N. 2024 'Rapid Evidence Synthesis: What is the health impact of poor housing?' University of Manchester, accessible online at: https://documents.manchester.ac.uk/display.aspx?DocID=72887#:~:text=There%20is%20low%20to%20moderate,number%20of%20falls%20at%20home

- Marmot M, Allen J, Boyce T, Goldblatt P, Morrison J. Health Equity in England: The Marmot Review 10 Years On. Institute of Health Equity; 2020 (health.org.uk/publications/reports/the-marmot-review-10-years-on).

- NICE. (2015). Excess winter deaths and illness and the health risks associated with cold homes. Guidance and guidelines | NICE. In *National Institute for Health and Care Excellence Guideline*. https://www.nice.org.uk/guidance/ng6

- NICE. (2017). Air pollution: outdoor air quality and health. In *National Institute for Health and Care Excellence Guideline*. https://doi.org/10.12968/bjca.2019.0044

- NICE. (2020). Indoor air quality at home. In *National Institute for Health and Care Excellence Guideline*. https://www.nice.org.uk/guidance/ng149

- Nicol, et al. (2018) BRE – The full cost of poor housing in Wales
The_Cost_of_Poor_Housing_report_English_final2-1.pdf (phwwhocc.co.uk)

- Nicol S, Garrett H, Woodfine L, Watkins G, Woodham A. (2019). The full cost of poor housing in Wales, Building Research Establishment Ltd, Public Health Wales, Welsh Government. BRE – The full cost of poor housing in Wales
The_Cost_of_Poor_Housing_report_English_final2-1.pdf (phwwhocc.co.uk)

- Nussbaumer-Streit B, et al. (2023) Cochrane Rapid Reviews Methods Group. Rapid reviews methods series: Guidance on team considerations, study selection, data extraction and risk of bias assessment. BMJ Evid Based Med. 2023 Nov 22;28(6):418-423.
- O'Sullivan, A, Young, G, Brittain, A, Dowie, A, Gibb, K, MacLennan, D and McLaren, J (2004) *Local Housing Systems Analysis: Good Practice Guide*. Communities Scotland: Edinburgh
- Palacios, J., Eichholtz, P., Kok, N., Aydin E. The impact of housing conditions on health outcomes, Real Estate Economics, 2021; 49 (4) pp. 1172-2000. https://onlinelibrary.wiley.com/doi/10.1111/1540-6229.12317

- Palacios, J., Eichholtz, P., Kok, N., Aydin E. The impact of housing conditions on health outcomes, Real Estate Economics, 2021; 49 (4) pp. 1172-2000. https://onlinelibrary.wiley.com/doi/10.1111/1540-6229.12317

- Piddington, J,. Garrett, H., Custard, M. *The Housing Stock of The United Kingdom*, BRE Trust, Editor. 2020.

- Public Health Scotland; '*Public Health approach to prevention: the building blocks of health'* October 2024, Available online at: https://publichealthscotland.scot/about-us/what-we-do-and-how-we-work/public-health-approach-to-prevention/the-building-blocks-of-health/

- ScotPHO (2024) Housing: Introduction (cited January 2025) https://www.scotpho.org.uk/wider-determinants/housing/introduction/
- Scottish Government, *Scottish House Conditions Survey 2022*, available online at: https://www.gov.scot/collections/scottish-house-condition-survey/

- Scottish Government, *Scottish House Condition Survey: 2023 Key Findings*. (2025). Available online at : https://www.gov.scot/publications/scottish-house-condition-survey-2023-key-findings/

- Scottish Government, '*Housing to 2040'*, Published March 2021. Available online at : https://www.gov.scot/publications/housing-2040-2/

- Scottish Government; '*Scotland's population Health framework 2025-2025'* june 2025, Available online at https://www.gov.scot/publications/scotlands-population-health-framework/

- Shelter (2024). *What is the housing emergency in Scotland?* Available online at: https://scotland.shelter.org.uk/campaigning/what_is_the_housing_emergency.

- Shiels, E., Li, A., Mason, K., Bentley, R., & Grocott, K.. Impact of housing quality improvements on the mental health of residents: A systematic review.. PROSPERO 2023 CRD42023445233. Online: https://www.crd.york.ac.uk/PROSPERO/view/CRD42023445233

- Thomson H, Thomas S, Sellstrom E, Petticrew M. The health impacts of housing improvement: a systematic review of intervention studies from 1887 to 2007. Am J Public Health. 2009 Nov;99 Suppl 3(Suppl 3):S681-92. doi: 10.2105/AJPH.2008.143909. PMID: 19890174; PMCID: PMC2774202.

- Thomson H, Thomas S, Sellstrom E, Petticrew M. Housing improvements for health and associated socio-economic outcomes. Cochrane Database of Systematic Reviews 2013, Issue 2. https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD008657.pub2/full

- UK Health Security Agency, Health Effects of Climate Change (HECC) in the UK: 2023 Report, Chapter 5. Impact of climate change policies on indoor environmental quality and health in UK housing' https://assets.publishing.service.gov.uk/media/65704f719462260721c569ca/HECC-report-2023-chapter-5-indoor-air-quality.pdf

- Whiting, P., et al. (2016). ROBIS: A new tool to assess risk of bias in systematic reviews was developed. *Journal of Clinical Epidemiology*, *69*, 225–234. https://doi.org/10.1016/j.jclinepi.2015.06.005
- WHO, 'Housing and Health Guidelines'. Geneva: World Health Organization; 2018. 6, Injury hazards. Available from: https://www.ncbi.nlm.nih.gov/books/NBK535287/
- WHO, 'Fact Sheets: Radon' 2023. Available online at: /www.who.int/news-room/fact-sheets/detail/radon-and-health

Appendix 1: Housing Quality & Health Search Strategy – Economics Evidence Review

Aim

Undertake a rapid evidence review of existing literature and data to (i) establish the current evidence on costs and the wide range of potential benefits of investing in good quality housing as compared to poor-quality housing and (ii) identify evidence gaps. This will inform on the quality of existing studies, the types of analyses that have been undertaken and could be used to inform/ parameterise a cost-consequence analysis based on the existing evidence comparing good quality to poor-quality housing.

Search Strategy

Objective / Purpose: search and utilise economic evidence to identify existing gaps, and inform, develop and ideally parameterise the cost-consequence analysis. We are interested in the range of outcomes, the amount and quality of the evidence on these and the uncertainty surrounding them. As well as identifying evidence gaps.

WP1 Questions

1. What is the existing evidence in Scotland, UK and from other countries and context on impact and benefits of good quality housing?
2. What health and non-health outcomes have been used to assess 'effectiveness' or quantify the impact/benefits of poor and good quality housing?
    a. What is the strength and quality of this evidence?
    b. What are the evidence gaps?
3. What economic evaluations have been carried out in this context?
    a. What is the quality of economic evidence
    b. what types of economic frameworks, perspectives and methods have been used?

Re-define questions based on recent reports and reviews

1. What economic evaluations have been carried out on impact and benefits of good quality housing?
    a. What outcomes have been used to inform the economic analyses
    b. what types of economic frameworks, perspectives and methods have been used?
    c. What is the quality of economic evidence
    d. Are there any remaining evidence gaps (what hasn't been done)

Search Plan

Adapt the search strategy from Thomson et al. 2013, use the housing and improvement terms, and combine with Economics terms filters from SIGN methodology search filers – economics. https://www.sign.ac.uk/using-our-guidelines/methodology/search-filters/

Population: people living in poor or good quality housing

Intervention: good quality housing, investing in improvements, warmth or energy efficiency improvements, rebuilding new homes, retrofitting (types of housing can be broad – want to see what interventions and types are out there).

Comparator – poor-quality housing, current housing**,** relocation of housing

Outcomes: hazards, health outcomes (physical and mental health / injury), non-health, wellbeing, costs, economic outcomes, QALYs, DALYs, CBA. E.g. list the housing conditions, hazards and the health outcome/hazards identified in the BRE and those identified in Manchester review. Which of these have been used in economic analyses or costing studies.

- Housing Aspects -identified from Table 1 in the Manchester Review: (temperature, building type and materials, housing age, housing hazards (see below), lighting, air quality (indoor allergens, mould & damp, lead), Indirectly relevant aspects (tenure/precarity, crowding, indoor pollutants)
- Hazards: falls,
- Health: general health, asthma, respiratory, cardiovascular, blood pressure, COPD, sleep, infectious diseases, cancer, physical functioning, depression, mental health,
- Economic: costs, cost savings, Net Monetary Benefit, Quality Adjusted Life year (QALY), Disability adjusted life year (DALY), Incremental cost-effectiveness ratio

Databases: Medline, Embase, Cochrane whole, EconLit

Inclusion criteria include:

- RCTs, observational studies, cohort studies, reports. If we find any systematic reviews that are relevant e.g. of economic evaluations, we will keep aside but they fall out-with inclusion criteria remit.
- Economics: costing studies, full economic analyses (CEA, CUA, CBA, CCA, CMA).
- Comparison between poor-quality housing and better quality or moving between
- Must include the key outcomes of interest identified in search strategy and be an economic evaluation
- Housing type includes adapt Static homes/buildings. However, mobile homes and house boats are excluded (as per Thomson, 2013 review)
- Low-Middle income country relevant interventions can be included if they are a costing study or economic evaluations, but may be of less relevance to Scottish and UK context.

Exclusion Criteria:

- Exclude if not a costing or economic evaluation.
- Exclude if a specific health intervention for a population identified via their housing. i.e. not a housing improvement study.
- Related areas such as housing insecurity, rising house prices to be excluded as this is a poverty related issue not a housing quality or improvement issue, so out with scope. Such related areas of interest can be noted as an aside for funders

- Poverty related housing issues and outcomes of interest but not primary aim – exclude but keep aside for the funders.

PICO Search Terms

- Population - Housing quality terms (adapted from Thomson et al 2013)
- Intervention terms – improvements, retrofitting etc. (adapted from Thomson et al 2013)
- Economic terms (adapted SIGN methods economic filter)

Search Terms

Search strategy designed for Medline (ovid) was adapted to search other databases

Ovid MEDLINE(R) ALL <1946 to January, 2025>

1 housing/

2 housing for the elderly/

3 public housing/

4 ((renovat$ or repair$) adj3 (home or homes or house or houses or housing)).ti,ab.

5 ((mite or mites or rat or rats or mouse or mice or cockroach$ or vermin or flea or fleas or infest$) adj3 (home or homes or house or houses or housing)).ti,ab.

6 ((sanitation or sanitary) adj3 (home or homes or house or houses or housing)).ti,ab.

7 ((mold or mould or moldy or mouldy) adj3 (home or homes or house or houses or housing)).ti,ab.

8 ((damp$ or humid$) adj3 (home or homes or house or houses or housing)).ti,ab.

9 (heating adj3 (home or homes or house or houses or housing)).ti,ab.

10 ((retrofit$ or retro fit$) adj3 (home or homes or house or houses or housing)).ti,ab.

11 (ventilation adj3 (home or homes or house or houses or housing)).ti,ab.

12 (insulat$ adj3 (home or homes or house or houses or housing)).ti,ab.

13 (refurbish$ adj3 (home or homes or house or houses or housing)).ti,ab.

14 ((crowd$ or overcrowd$) adj3 (home or homes or house or houses or housing)).ti,ab.

15 (double glaz$ adj3 (home or homes or house or houses or housing)).ti,ab.

16 ((draft$ or draught$) adj3 (home or homes or house or houses or housing)).ti,ab.

17 (allergen$ adj3 (home or homes or house or houses or housing)).ti,ab.

18 Air Pollution, Indoor/

19 indoor air qualit$.ti,ab.

20 (towerblock$ or tower block$).ti,ab.

21 apartment$.ti,ab.

22 (bedsit$ or bed sit$).ti,ab.

23 (highrise$ or high rise$).ti,ab.

24 (multistor$ or multi stor$).ti,ab.

25 (bungalow$ or flats).ti,ab.

26 landlord$.ti,ab.

27 rehous$.ti,ab.

28 (homeowner$ or home owner$ or tenant$ or owner$ occup$).ti,ab.

29 dwellings.ti,ab.

30 squatter$.ti,ab.

31 or/1-30

32 (reduc$ or increas$ or decreas$ or evaluat$ or change$ or changing or intervention$ or grow$).ti,ab.

33 (improv$ or better or worse$ or eBect$ or achieve$ or comfort or morale or harmful or impact$ or gain$).ti,ab.

34 32 or 33

35 ((reduc$ or increas$ or decreas$ or evaluat$ or change$ or changing or intervention$ or grow$ or (improv$ or better or worse$ or eBect $ or achieve$ or comfort or morale or harmful or impact$ or gain$)) adj3 housing).ti,ab.

36 31 and 34

37 35 or 36

38 homeless$.ti,ab.

39 exp homeless persons/

40 animal housing/

41 or/38-40

42 Economics/

43 "costs and cost analysis"/

44	Cost allocation/

45	exp Cost-Effectiveness Analysis/

46	exp Cost-benefit analysis/

47	exp Cost control/

48	Cost savings/

49	Cost of illness/

50	Cost sharing/

51	Health care costs/

52	Employer health costs/

53	Hospital costs/

54	Health expenditures/

55	Value of life/

56	exp economics, hospital/

57	exp economics, medical/

58	(low adj cost).mp.

59	(high adj cost).mp.

60	(health?care adj cost$).mp.

61	(cost adj estimate$).mp.

62	(cost adj variable).mp.

63	(unit adj cost$).mp.

64	(economic$ or pharmacoeconomic$ or price$ or pricing).tw.

65	42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51 or 52 or 53 or 54 or 55 or 56 or 57 or 58 or 59 or 60 or 61 or 62 or 63 or 64

Appendix 2: Summary of economic evidence review

Appendix 2.1: Data Extraction Table

*Presented by UK study first (for relevance to Scottish context) then alphabetically thereafter

Study*	Country	Year of costing	Type of Intervention	Study Type	Type of Economic Evaluation	Perspective	Economic Model Type	Method for Uncertainty Analysis	Economic Results	Authors' Conclusion
Bray et al., 2017	UK	2010	Energy-efficient retrofits (boilers, windows)	Observational – Historical cohort study with economic analysis	Cost-consequence analysis (CCA)	Societal	None (descriptive statistical and bootstrap methods)	Bootstrapping; subgroup & seasonality analyses	Mean intervention cost = £3725.26; 6-month NHS health service cost savings = £94.79/household; outpatient and A&E visits significantly reduced	Warmth-related retrofits improved health, anxiety, financial satisfaction, and heating capability. May be cost-effective in older populations despite modest short-term NHS savings.
Coskeran et al., 2006	UK	2003	Radon protection – membrane and sump (current) vs. post-construction testing and remediation (alternative)	Comparative case study	Cost-effectiveness analysis (CEA)	Societal	QALY-based static model	One-way sensitivity analysis (occupancy, discount rate, utility values, costs, AM/GM)	Cost per QALY gained: £2869 (alternative) vs. £6182 (current); both below NICE threshold; worst-case still cost-effective	The alternative regime is more cost-effective than the current approach; policy should consider targeted remediation post-construction

Coskeran et al., 2005	UK	2002	Radon remediation in homes (Fan-based radon extraction systems installed in homes >200 Bq/m³)	Model-based economic evaluation	Cost-effectiveness analysis (CEA)	Societal	Static model estimating life-years gained and cost per life-year	Scenario analyses (varying discount rates, % uptake, remediation rates)	Cost per life-year gained: £5,387–£7,770 (3% discount), all <£30,000 threshold; BCR >1 in some PCTs; cost-effective under NICE/Gerber–Phelps criteria	Radon remediation in homes is cost-effective for health gains. Higher remediation rates and targeting high-radon areas improve cost-effectiveness. PCTs should promote remediation in affected areas.
Coskeran et al., 2007	UK	Not specified (Based on 2004 values)	Radon-proof membranes in new homes	Model-based economic evaluation	Cost-effectiveness analysis (CEA)	Societal	QALY-based static model with discounted cost-effectiveness ratio	One-way sensitivity analysis and worst/best-case scenarios	Base case: £6,182/QALY gained; Best case: £1,893/QALY; Worst case: £56,531/QALY; Still cost-effective under NICE threshold	Installing radon-proof membranes is cost-effective in high-radon areas and compares favourably with other health interventions; supports current regulations and suggests further evaluation for broader implementation.

Coskeran et al., 2009	UK	2006	Various radon protection strategies (membranes, sumps, post-construction testing)	Model-based economic evaluation	Cost-effectiveness analysis (CEA)	Societal	QALY-based static model	Bootstrapping, scenario testing	Cost per QALY: No radon protection during construction (£2870), Option install a radon membrane only during construction (£3026), Option Install both a radon membrane and a sump (£4286), Option Install both a radon membrane and a sump with limited testing and remediation (£4580), Option Current regulatory regime (£6182); all but Current regulatory regime cost-effective under NICE threshold	Alternative regulatory regimes (esp. post-construction testing with selective remediation) are more cost-effective than the current approach; support for policy change toward mandatory testing post-construction.

Denman et al., 2005	UK	2003	Radon testing and remediation (fan-based systems)	Model-based economic evaluation	Cost-effectiveness analysis (CEA)	Societal	Static cost-effectiveness model	Scenario analysis (varying prevalence, discount rates, and risk profiles)	Cost per lung cancer averted (annualised): £963 (1997 est.) to £29400 (2003 min est.); Annualised cost per lung cancer averted in current population: £527k–£1.3M; Cost per life-year gained: £17,155 (2001 prices); All PCTs except Northampton town met cost-effectiveness threshold	Radon remediation is cost-effective in high-risk areas with high remediation uptake. However, uptake is low, and those remediating are often at lower risk. Public health messaging and financial support are needed to improve impact and equity.
Dymond et al., 2021	UK	2019	Both Home Retrofits and behavioural interventions	Modelling study based on secondary data	cost-saving threshold analysis	NHS perspective	Not a full economic evaluation Uses cost-saving threshold model Scenario-based and threshold-based analysis	Two-way sensitivity analysis: • Varied intervention cost (£0–£250) and effectiveness (0–10%) • Identified combinations where the intervention becomes cost-saving	Interventions could be cost-saving depending on cost-effectiveness thresholds. E.g., at £50 cost, a 2% asthma symptom reduction yields £6.4M savings in high-risk small homes. At 10% effectiveness and 50% implementation, free interventions could save £356M (asthma), £240M (GAD), £223M (rhinitis), and £165M (COPD) over 5 years.	Interventions to reduce indoor air pollution can be cost-saving, especially in high-risk homes. Effectiveness and risk profile are the strongest predictors of cost-savings

								• Multiple scenarios: • Risk profiles: low vs. extreme • Dwelling conditions: damp, non-decent, small floor area • Health conditions: asthma, COPD, allergic rhinitis, GAD		
Denman et al., 2008	UK	2003	Radon remediation at varying Action Levels (e.g., 125–500 Bq/m³)	Model-based economic evaluation	Cost-effectiveness analysis (CEA)	Societal	Static model – cost per cancer averted and dose saved	Scenario analysis across Action Levels (125–500 Bq/m³)	Cost-effectiveness varies by Action Level. Most cost-effective range: 200–300 Bq/m³. At 200 Bq/m³: ~21 lung cancers averted/year in Northamptonshire; cost ~£130,000. Lowering the Action Level to 125 Bq/m³ increases cost (~£203,880) but prevents more cancers (~32).	Reducing the Action Level below 200 Bq/m³ prevents more cancers but is less cost-effective. 200–300 Bq/m³ is the most efficient range. Supports current UK Action Level policy while noting public uptake and equity challenges.

									However, cost-effectiveness declines below 200 Bq/m³ due to diminishing returns.	
Rodgers et al., 2018	UK	Not specified	Housing upgrades to meet Welsh Housing Quality Standards (WHQS)	Natural experiment – retrospective longitudinal data linkage	Cost-consequence analysis (CCA)	Societal	Health resource impact model using incidence rate ratios and cost per hospital admission	Confidence intervals, subgroup and sensitivity analyses by cointervention and age group	Electrical upgrades associated with £198,455 savings per 1000 people (≥60) annually. £138 million invested in interventions. Significant reductions in emergency admissions for older adults linked to electrical, wall insulation, windows/doors, and garden paths. No significant effects for kitchens, bathrooms, or heating.	Targeted housing improvements (particularly electrical, insulation, and safety upgrades) reduced emergency hospital admissions and healthcare costs. Longitudinal evidence supports continued investment in quality housing for health improvement.
Baird et al., 2020	USA (Pittsburgh)	Not specified	Public-private HOPE VI reinvestment in low-income neighbourhood	Quasi-experimental (longitudinal panel)	Return on investment analysis (difference in difference)	Societal or public sector	difference-in-differences regression to measure the return per $1 million invested	Robustness checks, alternative functional forms	$10M investment: +0.95% residential, +2.7% commercial sales, â†“nonviolent crime	Significant positive effects; cities should anticipate gentrification-related displacement

Aldred et al., 2015	United States	2007	HVAC system with a commercially available activated carbon (AcC) filter	Model-based economic evaluation	Cost-benefit analysis (CBA)	Societal/public health	Integrated systems modelling combining: • Indoor ozone concentration modelling • Health impact estimation using DALYs • Monetized benefits and costs • Comparison of health-related benefits with filter installation and energy costs	Yes – extensive Monte Carlo simulation • Used 100,000 iterations to model uncertainty in: • Filter performance • Electricity costs • DALY valuation ($/DALY) • HVAC operation time • Also conducted one-way sensitivity analyses for key parameters	Mean benefit-to-cost (B/C) ratios for 2.5-cm (1-inch) filters: • 1.0 in 10 of 12 U.S. cities • Highest in Phoenix and Riverside (B/C ≈ 2.0) • Lower in Buffalo and Minneapolis due to mild climates and less A/C usage • In "optimal home" scenarios (high-efficiency filters, 100% fan run-time, high occupancy): • All cities showed B/C > 1.0 • B/C ratios ranged as high as 10–13	Activated carbon filters in residential HVAC systems can be cost-beneficial, especially in cities with high ozone levels and HVAC use. Effectiveness depends heavily on HVAC system run-time and filter performance. Benefits are skewed, with the largest gains in older adults and those with respiratory conditions.
Babu et al., 2007	India (Orissa)	Not specified	Household-level use of personal protection	Cross-sectional	Costing study	Household/ consumer level perspective	None	N/A	Mean monthly expenditure:	High usage of mosquito protection;

		measures (PPMs), including coils, vaporizers, sprays, smoke, and untreated bednets	observational survey					• Urban: ₹101 (USD ~$2.20) • Rural: ₹72 (USD ~$1.60) • Expenditure drivers (significant predictors): • Urban vs rural setting • Household income • Number of people in household • Number of sleeping rooms • Cost as % of income: • Urban: ~2.0% of per capita income • Rural: ~2.8% • Highest average monthly costs by product: • Vaporizing mats > Coils > Liquid vaporizers > Smoke	significant household cost burden; need for safer, affordable options and improved public mosquito control efforts

Bai et al., 2017	China	2015	Structural Insulated Panels (SIPs) in rural construction	Multi-criteria decision analysis	Multi-criteria with economic costing	Societal/infrastructure policy	AHP-Grey Correlation Analysis	Not conducted	Initial Investment (¥/m²): SIPs – ¥1050; Brick – ¥750 (lowest) - Life Cycle Cost (¥/m²/year): SIPs – ¥33.03 (better than brick: ¥41.98) - NPV: SIPs – ¥38,834.7 (highest) - Payback Period: SIPs – 19.21 years (shortest among alternatives) SIPs showed best economic performance overall	SIPs offer superior economic and carbon performance among alternatives
Chau et al., 2008	Hong Kong	2006	Air cleaners, behavioral changes, and relocation	Model-based economic evaluation	Cost-benefit analysis (CBA)	Societal	Mass-balance exposure model + concentration–response + monetary valuation	One-way sensitivity analysis (±20% changes, window behaviour scenarios)	Max BCR: 2.1 (elderly, air cleaner in cool season); max individual benefit: HK$2072 (adult), HK$1700 (elderly); relocation benefits lower	Air cleaners with windows closed, especially in cool season, offer highest health and economic benefits. Relocation and Behavioural changes offer limited gains. Resident behaviour (e.g., window opening) significantly affects outcomes.

Chapman et al., 2009	New Zealand	2004-2005	Retrofitting insulation in low-income housing	Cluster RCT with economic evaluation	Cost-benefit analysis (CBA)	Societal (health, energy, emissions)	Discounted present value model	Scenario analyses (5% vs 7% discount rates; 20 vs 30-year horizon)	BCR = 1.87 (5% discount), 1.59 (7%); NPV = NZ$1574/household; majority of benefits from reduced hospitalizations	Insulation retrofits are cost-beneficial with health, energy, and environmental co-benefits; compelling case for public investment
An et al., 2007	China (Guizhou Province)	Not specified	Stove replacement and health education to reduce arsenic exposure	Community-wide intervention study	Cost-effectiveness impression (costing + biomarker outcomes)	Public health perspective	None	Before-after exposure comparison	10,000 stoves installed at ~$500k; urinary arsenic dropped significantly	The study demonstrates that targeted health education, combined with low-cost home improvements and policy support, can effectively reduce environmental health risks in low-income communities.
Gaskin et al., 2019	Canada	Not specified	National radon policy scenarios in new and existing housing	Model-based economic evaluation	Cost-effectiveness analysis (CEA)	Societal	Markov life-table model	Scenario and sequential analysis	ICERs vary by scenario; best = passive + mitigation: <$25K/QALY	Mitigation is feasible and cost-effective across most provinces; supports incentives
Gaskin et al., 2020	Canada	2016	Radon mitigation in existing housing using two	Model-based economic evaluation	Cost-utility analysis (CUA)	Societal	Markov cohort + Discrete	Monte Carlo simulation (Markov),	Discounted ICERs ($/QALY):	Radon mitigation in existing housing is fairly

		modelling techniques				Event Simulation	population sampling (DES), scenario analysis for housing renewal and occupancy	- Markov model: $72,569 (200 Bq/m³), $68,758 (100 Bq/m³), $93,007 (50 Bq/m³) - DES model: $84,828 (200 Bq/m³), $76,917 (100 Bq/m³), $101,755 (50 Bq/m³) Lower ICERs with increased mitigation under tax credit scenario: as low as $54,621 (DES at 200 Bq/m³)	cost-effective in Canada, especially at increased testing/mitigation rates. Minimal structural uncertainty exists between model types. Public policy should consider promoting mitigation to reduce lung cancer burden.

Gaskin et al., 2021	Canada	2016	Radon mitigation: improved foundation membrane in new housing; mitigation in existing homes at 200 or 100 Bq/m³	Model-based economic evaluation	Cost-utility analysis (CUA)	Societal	Markov cohort model + Monte Carlo simulation	Monte Carlo simulations; regional scenario and sequential analyses	ICERs for new housing: $18,075–$58,454/QALY (except Nunavut: $340,482/QALY); ICERs for existing housing: $33,247–$61,960/QALY at 200 Bq/m³; More lung cancers averted in new housing (446 annually); Cost-effective in new housing across most regions; existing housing cost-effective in high-radon areas at 200 Bq/m³ threshold	Radon interventions are more cost-effective in new housing than in existing housing. Policy should support increased resistance measures in new construction and targeted remediation in high-radon areas.
Riggs et al., 2021	New Zealand	Not specified	Housing quality improvement (modelled as counterfactual to poor conditions)	Burden of disease / cost-of-illness study	Partial Economic evaluation -- Cost of illness	Societal	Attributable burden model using exposure–response and population attributable fractions	Range estimates; confidence intervals from literature; exposure variability modelled	Annual cost of unsafe housing: ~NZ$1 billion - Mortality cost (VSL): NZ$939M/year	Poor housing imposes substantial health and economic burdens in NZ. Damp/mould and fall risks are key contributors. Significant

									- Hospitalization: NZ$36M (damp), NZ$2.3M (cold), NZ$1.4M (crowding) - ACC injury claims: 115,555/year; NZ$102.3M/year	savings and health gains could be achieved through targeted housing improvements.
Robinson et al., 2021	Australia (Armidale)	2019	Reduction of wood heater pollution	Burden of disease / health cost analysis	Partial economic evaluation – health cost estimation	Societal	Exposure-response mortality model with VSLY cost analysis	Alternative exposure-response models (GEMM vs HRAPIE); 95% CI estimates	GEMM: 14 premature deaths, 210 YLL, $32.8M/year cost (95% CI: $27.0M–38.5M) HRAPIE: 6.7 deaths, 90.4 YLL, $14.8M/year cost	Wood heater pollution in Armidale causes substantial health and financial burden. Effective policies are needed: public education, financial incentives for cleaner heating, regulations restricting wood heater use.

Fisk et al., 2017	United States	2015	Improved filtration in residential and commercial HVAC systems, use of portable air cleaners	Simulation based economic evaluation	Cost-benefit analysis (CBA)	Societal/public health	Mass balance and mortality risk models with steady-state equations	Scenario and one-way sensitivity analysis (+/- 25% on key parameters, risk coefficients)	Benefit-to-cost ratios ranged from 3.9 to 133 depending on intervention and location. Portable HEPA cleaners had the highest benefits. Mortality reductions up to 2.4 deaths prevented per 10,000. Annual monetary benefit per person ranged from $110 to $2,025 depending on the scenario.	Filtration improvements in homes and commercial buildings are highly cost-beneficial. Policy should promote minimum filtration standards and home use of HEPA cleaners, especially for older adults.
Keall et al., 2017	New Zealand	2010	Home modifications to reduce fall hazards	Cluster RCT	Cost-benefit analysis (CBA)	Societal (social cost of injury)	None	Sensitivity analysis using 26% vs 33% injury reduction scenarios, DALY vs VOSL values, 8% discount rate	Cost per injury prevented: $980 (NZD 2012) Benefit-cost ratios: 8 (DALY-based) and 37 (VOSL-based) for 33% injury reduction For 26% reduction: BCR = 6 (DALY), 29 (VOSL)	Home modifications significantly reduce fall injury costs. The intervention is highly cost-beneficial under both DALY and VOSL models. Policy should support scaling of this intervention, especially for older adults and those with prior falls.
Liu et al., 2021	China	2009	Use of indoor air purifiers to reduce ambient PM2.5 exposure	Model-based economic evaluation	Cost-benefit analysis (CBA)	Societal	Two-stage Monte Carlo simulation (exposure-risk-	Two-stage Monte Carlo simulation; sensitivity	Deaths avoided: 93,200 (S1) to 207,900 (S4)	Air purifiers can be a cost-effective, interim solution to

							cost modelling)	tests on VSL, purifier life, filter cost	Net benefits: 131B RMB (S1), 90B (S2), –60B (S3), –317B (S4) BCRs: 2.6 (S1), 1.5 (S2), <1 in S3 and S4 S2 (PM2.5=25 µg/m³) recommended as most cost-effective national target	mitigate PM2.5-related mortality in China. Scenario S2 (25 µg/m³) is optimal with national net benefits. Government support is necessary to ensure equitable access.
Mishra et al., 2023	Australia	2021	Eradication of cold housing (raising indoor temp to ≥18°C)	Model-based economic evaluation	Cost–utility analysis (CUA)	Societal	Proportional Multistate Lifetable (PMSLT) with Monte Carlo simulation	2000-run Monte Carlo simulation; Tornado plots; univariate sensitivity analysis on key parameters	HALYs gained (discounted, 3%): 89,600 (95% UI: 47,700–177,000) Health expenditure saved: AUD$871 million (2021–2040) Income gain: AUD$4.35 billion Greater benefits in most deprived groups (6.1x HALYs vs least deprived)	Eradicating cold housing would yield significant health, equity, and economic benefits. Respiratory and mental health effects contribute most. More research is needed on causality magnitude, but policy action should not be delayed given likely large benefits.

Svensson et al., 2018	Sweden	2012	Reducing indoor radon levels to 100 Bq/m³ (from 200 Bq/m³)	Model-based economic evaluation	Cost-effectiveness analysis (CEA)	Societal	Decision-analytic model with Monte Carlo and deterministic sensitivity analyses	Tornado diagram + Monte Carlo simulation (5000 iterations)	Existing homes: 925,053 SEK/QALY (healthcare), 1.22M SEK/QALY (societal) New homes: 103,534 SEK/QALY (healthcare), 366,672 SEK/QALY (societal) Cost-effective only for new homes at Swedish threshold (500,000 SEK/QALY)	Lowering radon levels to 100 Bq/m³ is cost-effective in new homes, but not in existing homes. Policy should focus on enforcing the current 200 Bq/m³ standard in the existing housing stock.
Uppal et al., 2021	Canada	2018	Social/behavioural risk reduction such as tobacco use, heavy drinking, food insecurity and overcrowding mitigation	Model-based economic evaluation	Cost-effectiveness analysis (CEA)	Government/ Payer	Dynamic + decision-tree model	Probabilistic Sensitivity Analysis (10,000 simulations), tornado diagrams, scenario analysis on intervention effects	Tobacco reduction ICER: $49,671/QALY Combined all strategies: ICER ~$13.9M/QALY Overcrowding reduction: high cost, minimal prevalence impact (0.49%)	Tobacco reduction is the most cost-effective TB prevention strategy. Overcrowding reduction is costly but has potential. Community-led approaches are essential for sustainable public health gains.

Guo et al., 2022	China	Not specified	Clean heating transition (multiple strategies including coal-to-gas, electricity, ISH, improved CH)	Model-based economic evaluation	Cost-benefit analysis (CBA)	Societal	Gridded (5x5 km) PM2.5 dispersion modelling (AERMOD) + health monetization using VSL	Monte Carlo simulation (1000 iterations); probabilistic sensitivity analysis on PM2.5 estimates and health parameters	Improved CH strategy reduced PM2.5 emissions to 1/5th of baseline; health cases dropped from 63,148 to 8,134; Total net social benefit: 1796.95 million CNY – highest among all strategies. Some strategies caused net social losses in rural areas but delivered urban health gains.	A differentiated clean heating strategy that considers urban-rural variations maximizes social welfare. Improved CH is most cost-beneficial but requires careful policy design to address rural equity and heating poverty.
Irfan et al., 2021	Pakistan	Not specified	Interventions to reduce indoor air pollution (biogas, LPG, natural gas, electric stove, improved cookstove)	Model-based economic evaluation	Cost-benefit analysis (CBA)	Societal	Discounted benefit-cost model (WHO guidelines)	Scenario analysis (optimistic and pessimistic); sensitivity to discount rates (3%, 7.5%, 12%) and assumptions about benefits/costs	Benefit-Cost Ratios (BCRs): - LPG: 4.64–4.43 - Natural gas: 4.64–4.30 - Electric stove: 3.07–2.83 - Biogas: 2.67–2.41 - ICS: 0.38 (not cost-beneficial)	LPG is the most cost-effective intervention for reducing indoor air pollution in Pakistan. Natural gas and electric stoves are also beneficial but face infrastructure constraints. ICS is not cost-effective due to limited health gains and continued use of solid fuel.

									NPVs (in PKR): LPG ~338–170 billion; Natural gas ~337–165 billion; Electric stove ~287–133 billion; ICS: Negative NPV	Findings support adoption of cleaner fuels.
Katona et al., 2005	Hungary	2002	Ventilation strategies to reduce radon concentration	Model-based economic evaluation	Cost-benefit analysis (CBA)	Societal	Dynamic differential equation model; includes dose, ventilation cost, radon kinetics	Monte Carlo simulation; parameter range testing (e.g. deposition, resuspension, temperature)	Optimal ventilation rate: 0.22–0.66 h^{-1} depending on radon entry rate Optimal indoor radon concentration: 160–210 Bq/m^3 Periodic ventilation reduces inhalation dose by 30–70% vs. continuous ventilation for same cost	Ventilation can economically reduce radon exposure, especially with periodic strategies. Recommended action level: ~400 Bq/m^3 considering local heating cost and uncertainty. Periodic ventilation is more effective than continuous under same cost.

Appendix 2.2: Economic Evaluation Review References of included studies

1. Coskeran T, Denman A, Phillips P, Tornberg R. A cost-effectiveness analysis of domestic radon remediation in four primary care trusts located in Northamptonshire, UK. Health policy (Amsterdam, Netherlands). 2005;71(1):43-56.

2. Coskeran T, Denman A, Phillips P, Tornberg R. A cost-effectiveness analysis of radon protection methods in domestic properties: a comparative case study in Brixworth, Northamptonshire, UK. Journal of Environmental Radioactivity. 2006;91(1-2):73-89.

3. Coskeran T, Denman A, Phillips P, Tornberg R. The cost-effectiveness of radon-proof membranes in new homes: A case study from Brixworth, Northamptonshire, UK. Health Policy. 2007;81(2-3):195

4. Coskeran T, Denman A, Phillips P, Tornberg R. A critical evaluation of the cost-effectiveness of radon protection methods in new homes in a radon affected area of England. Environment International. 2009;35(6):943-51.

5. Denman A, Groves-Kirkby C, Coskeran T, Parkinson S, Phillips P, Tornberg R. Evaluating the health benefits and cost-effectiveness of the radon remediation programme in domestic properties in Northamptonshire, UK. Health policy (Amsterdam, Netherlands). 2005;73(2):139-50.

6. Denman AR, Coskeran T, Phillips PS, Crockett RGM, Tornberg R, Groves-Kirkby CJ. Lowering the UK domestic radon Action Level to prevent more lung cancers--is it cost-effective? Journal of radiological protection : official journal of the Society for Radiological Protection. 2008;28(1):61-71.

7. Dymond A, Mealing S, McMaster J, Holmes H, Owen L. Indoor air quality at home - An economic analysis. International Journal of Environmental Research and Public Health. 2021;18(4):1

8. Rodgers SE, Bailey R, Johnson R, Poortinga W, Smith R, Berridge D, et al. Health impact, and economic value, of meeting housing quality standards: a retrospective longitudinal data linkage study. 2018.

9. Baird M, Schwartz H, Hunter G, Gary-Webb TL, Ghosh-Dastidar B, Dubowitz T, et al. Does Large-Scale Neighborhood Reinvestment Work? Effects of Public-Private Real Estate

Investment on Local Sales Prices, Rental Prices, and Crime Rates. Housing policy debate. 2020;30(2):164-90.

10. Bray N, Burns P, Jones A, Winrow E, Edwards RT. Costs and outcomes of improving population health through better social housing: a cohort study and economic analysis. International journal of public health. 2017;62(9):1039

11. Aldred JR, Darling E, Morrison G, Siegel J, Corsi RL. Benefit-cost analysis of commercially available activated carbon filters for indoor ozone removal in single-family homes. Indoor air. 2016;26(3):501

12. Babu BV, Mishra S, Swain BK. Personal-protection measures against mosquitoes: A study of practices and costs in a district, in the Indian state of Orissa, where malaria and lymphatic filariasis are co-endemic. Annals of Tropical Medicine and Parasitology. 2007;101(7):601

13. Bai L, Wang H, Shi C, Du Q, Li Y. Assessment of SIP Buildings for Sustainable Development in Rural China Using AHP-Grey Correlation Analysis. International Journal of Environmental Research and Public Health. 2017;14(11).

14. Chau CK, Hui WK, Tse MS. Valuing the health benefits of improving indoor air quality in residences. The Science of the total environment. 2008;394(1):25-38.

15. Chapman R, Howden-Chapman P, Viggers H, O'Dea D, Kennedy M. Retrofitting houses with insulation: A cost-benefit analysis of a randomised community trial. Journal of Epidemiology and Community Health. 2009;63(4):271

16. An D, Li D, Liang Y, Jing Z. Unventilated indoor coal-fired stoves in Guizhou province, China: Reduction of arsenic exposure through behavior changes resulting from mitigation and health education in populations with arsenicosis. Environmental Health Perspectives. 2007;115(4):659

17. Gaskin J, Coyle D, Whyte J, Birkett N, Krewksi D. A cost effectiveness analysis of interventions to reduce residential radon exposure in Canada. Journal of Environmental Management. 2019;247:449

18. Gaskin J, Whyte J, Coyle D. An assessment of uncertainty using two different modelling techniques to estimate the cost effectiveness of mitigating radon in existing housing in Canada. Science of the Total Environment. 2020;724:138092.

19. Gaskin J, Whyte J, Zhou LG, Coyle D. Regional cost effectiveness analyses for increasing radon protection strategies in housing in Canada. Journal of Environmental Radioactivity. 2021;240:106752.

20. Riggs L, Keall M, Howden-Chapman P, Baker MG. Environmental burden of disease from unsafe and substandard housing, New Zealand, 2010-2017. Bulletin of the World Health Organization. 2021;99(4):259-70.

21. Robinson DL, Horsley JA, Johnston FH, Morgan GG. The effects on mortality and the associated financial costs of wood heater pollution in a regional Australian city. The Medical journal of Australia. 2021;215(6):269-72.

22. Fisk WJ, Chan WR. Effectiveness and cost of reducing particle-related mortality with particle filtration. Indoor air. 2017;27(5):909

23. Keall MD, Pierse N, Howden-Chapman P, Guria J, Cunningham CW, Baker MG. Cost-benefit analysis of fall injuries prevented by a programme of home modifications: a cluster randomised controlled trial. Injury prevention : journal of the International Society for Child and Adolescent Injury Prevention. 2017;23(1):22

24. Liu Y, Zhou B, Wang J, Zhao B. Health benefits and cost of using air purifiers to reduce exposure to ambient fine particulate pollution in China. Journal of Hazardous Materials. 2021;414:125540.

25. Mishra SR, Wilson T, Andrabi H, Ouakrim DA, Li A, Akpan E, et al. The total health gains and cost savings of eradicating cold housing in Australia. Social Science and Medicine. 2023;334:115954.

26. Svensson M, Barregard L, Axelsson G, Andersson E. A cost-effectiveness analysis of lowering residential radon levels in Sweden-Results from a modelling study. Health policy (Amsterdam, Netherlands). 2018;122(6):687-92.

27. Uppal A, Oxlade O, Nsengiyumva NP, N'Diaye DS, Alvarez GG, Schwartzman K. Social and behavioral risk reduction strategies for tuberculosis prevention in Canadian Inuit communities: a cost-effectiveness analysis. BMC public health. 2021;21(1):280.

28. Guo X, Jia C, Xiao B. Spatial variations of PM<ovid:sub>2.5</ovid:sub> emissions and social welfare induced by clean heating transition: A gridded cost-benefit analysis. The Science of the total environment. 2022;826:154065.

29. Irfan M, Cameron MP, Hassan G. Interventions to mitigate indoor air pollution: A cost-benefit analysis. PloS one. 2021;16(9):e0257543.

30. Katona T, Kanyar B, Somlai J. Cost assessment of ventilation and averted dose due to radon in dwellings. Journal of Environmental Radioactivity. 2005;79(2):223

Appendix 3: Additional information underlying the Section 2.2 Scottish context cost analysis

A.3.1 Breakdown of all steps for the costing estimation, example for NHS England costs.

1. Number of category 1 hazards related to excess of cold in England from BRE report

Number of hazards	Tot NHS cost	NHS cost per dwelling (£)
835,829	857196218	1026

2. Adjust costs to 2024 using inflation indices:

	NHS cost	NHS cost per dwelling (£)
		1258

3. Adjust total NHS costs of English hazards:

£1,678,386,538

4. Estimate Scottish costs per dwelling:
   N. of dwelling with excess of cold * average NHS cost for hazard=
   140,000*£1258 = £176,109,973
5. Doing point 3 for all the other 9 hazards identified: £349,692,690.4. This is the Scottish equivalent cost for the 9 hazards or which there was Scottish data.

6. To estimate the total cost for Scotland (across all 26 hazards in BRE reports) we first calculate the weight of the 9 identified hazards in England across the full 26 hazards: 0.66

7. Projecting the figure for a total costs in Scotland based on the English weight:

   £349,692,690.4/0.66=529568089.8

Table A3.1. Weight for total cost to mitigate of each hazard across the three Nations with BRE reports

Hazard	England	Northern Ireland	Wales
Carbon monoxide	0.001	0.002	0.001
Collision and entrapment	0.001	-	0.003
Overcrowding	0.074	-	0.013
Damp and mould growth	0.027	0.099	0.082
Domestic hygiene	0.007	0.043	0.013
Electrical problems	0.002	0.024	0.009
Entry by intruders	0.002	0.014	0.003
Excess cold	0.606	0.205	0.335
Excess heat	0.000	-	-
Explosions	-	0.000	-
Falls - baths	0.001	-	0.002
Falls between levels	0.132	0.101	0.176
Falls on stairs	0.023	0.062	0.175
Falls on the level	0.036	0.114	0.062
Fire	0.048	0.087	0.044
Food safety	0.005	0.112	0.011
Hot surfaces	0.011	0.000	0.025
Lead	0.008	0.020	0.007
Lighting	-	0.022	-
Noise	0.001	-	-
Ergonomics	0.001	0.040	0.007
Radon	0.001	0.008	0.001
Sanitation (Personal hygiene)	0.013	0.023	0.020
Structural collapse	0.001	0.010	0.010
Uncombusted fuel gas	0.000	0.000	-
Water supply	-	0.012	-
Total cost of any Category 1 hazard	9,826,188,952	305,054,048	584,199,138
Total cost of hazard summed	9,825,136,438	323,875,283	590,850,334

Table A3.2. Weighting for total NHS cost per annum of each hazard across the three Nations with BRE reports

Hazard	England	Northern Ireland	Wales
Carbon monoxide	0.002	0.003	0.001
Collision and entrapment	0.006	-	0.003
Overcrowding	0.004	-	0.000
Damp and mould growth	0.028	0.012	0.032
Domestic hygiene	0.003	0.010	0.004
Electrical problems	0.001	0.007	0.004
Entry by intruders	0.006	0.031	0.004

Excess cold	0.627	0.378	0.433
Excess heat	0.000	0.001	-
Explosions	-	-	-
Falls - baths	0.002	-	0.003
Falls on stairs	0.160	0.217	0.168
Falls between levels	0.037	0.053	0.094
Falls on the level	0.076	0.159	0.175
Fire	0.013	0.019	0.038
Food safety	0.002	0.021	0.004
Hot surfaces	0.013	0.011	0.019
Lead	0.006	0.011	0.003
Lighting	-	0.005	-
Noise	0.002	-	-
Ergonomics	0.003	0.024	0.004
Radon	0.002	0.014	0.001
Sanitation (Personal hygiene)	0.007	0.012	0.008
Structural collapse	0.001	0.001	0.002
Uncombusted fuel gas	-	0.001	-
Water supply	-	0.012	-
Total cost of any Category 1 hazard	9,826,188,952	305,054,048	584,199,138
Total cost of hazard summed	9,825,136,438	323,875,283	590,850,334

Addendum to Housing Quality and Health Report

Summary of Housing Quality Stakeholder Workshop

Wednesday 12 June 2025, 13:00 to 15:00

Room 225, Advanced Research Centre

Theme	Core insights
1. Investment prioritisation & economic case	Poor-quality housing is a social issue that creates demand for health and care services. Financial demand and political pressures create 'short-termism' in the NHS. The Scottish Government Population Health Framework seeks to address this by prioritising long-term prevention (improved housing, health, child poverty, long term outcomes). This is a positive development in the current landscape. Policymakers will want a short list of the top 1–3 interventions, their effects, timescales and return-on-investment (ROI). Green Book methodologies in a cost–benefit analysis (CBA) or ROI are needed to make the case.
2. Evidence & data gaps	Longitudinal evidence is still needed to link housing improvements to poverty reduction, mental-health gains and educational attainment. Existing administrative datasets from various sources are available (housing-association works, Energy Saving Trust, census data, health records). There are barriers to access and link these but also opportunities to develop a linked longitudinal (treatment controlled) observational study and work up as a research grant application.
3. Regulatory & policy landscape	Social-housing investment (and data) is often driven by statutory regulations, but levers for private landlords and owner-occupiers are weaker. England's Housing Health & Safety Rating System (HHSRS) is viewed as a possible template for Scotland. The Scottish House Conditions Survey (SHCS) doesn't collect 'additional hazards' e.g. falls, as is done in England, as this is not a regulatory requirement in Scotland. A recommendation was made that the Scottish Government and SHCS, could be asked to extend SHCS, to include falls and other relevant hazards.
4. Climate change & retrofit	Carbon and climate change commitments are integral. Retrofitting is urgent and can improve housing quality while meeting energy efficiency targets, yet the up-front capital costs are prohibitive. Reframing retrofit as a net social and fiscal benefit, while highlighting

Theme	Core insights
	any unintended consequences, and consequences if action is delayed, was deemed critical.
5. Lived experience & public acceptability	Integrating tenant stories (e.g., Cairns Tenant Testimonials) with quantitative evidence could strengthen the social-value case and build public support. Housing structure and demographics are critical elements to consider. Strathclyde University (and Prof Ade Kearns) have published work on the collective narrative from lived experiences with different housing types.
6. Communication & audiences	The primary audience for this and future work needs to be the Scottish Government, but tailored messaging is needed for health, housing and climate teams. Housing and Health systems frequently work in parallel rather than in partnership, often remaining siloed and may have different audiences. The Population Health Framework is a 10-year strategy to improve life expectancy and reduce inequalities within life expectancy, published alongside an Evidence Narrative.
7. Research & publication plans	Potential outputs: a short policy brief summarising the work which makes reference to the new Population Health Framework. It was recommended this framework be added as a reference to the main study report. An academic article in *Real Estate Economics* or a public-health journal.

Identified Next Steps

1. **Policy brief** summarising the work and setting out the three highest-impact interventions, costs, timelines and health-equity gains.
2. **Undertake a housing-archetype CBA**: segment stock (e.g., pre-1919 tenements, post-war social housing, rural detached) and what interventions would be required for the different housing types. Could allocate public vs private or mix of funding. Use Green Book methodologies for ROI or CBA.
3. **Extend the SHCS** to include falls and other relevant hazards which would allow comparable assessments of Scotland with the BRE data for the rest of the UK nations. This is a recommendation for the Scottish Government housing statistics department or SCHS.
4. **Design a data-linkage pilot** with a willing housing association or local authority to track retrofit works against resident health and poverty indicators.
5. **Longitudinal study** linking the impact of child poverty and child mental health

6. **Hold workshops with civil servants** (health, housing, climate) to capture their perspectives, validate evidence needs and refine messaging
7. **Utilise the lived-experience material** from Strathclyde and Cairns Housing Association (short videos or case studies) could support the main report.
8. **Scottish Government Policy fellowship:** ESRC and the Scottish Government have recently announced a fellowship in Housing, systems thinking and evidence. Opportunities to collaborate with candidates or apply in future calls.