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# The Case for Investing in Prevention: Housing



This is one in a series of short reports examining the case for investment in prevention activities. Each report includes a review of the literature which, while not exhaustive, aims to provide an overview for the reader and sign-post to further information for those requiring greater detail. The reports use primarily health economic intelligence and aim to present this in a non-specialist format along with selected elements of epidemiology and policy in Wales in order to provide context. We hope you find these reports of use and always welcome feedback that allows us to improve the quality and utility of our work.

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## Executive summary

### Should there be investment to improve housing?

A range of adverse physical and mental health outcomes have been linked to poor quality housing through issues including mould, poor warmth and energy efficiency, infestations, second-hand smoke, overcrowding, noise, lack of green space and toxins<sup>1,2</sup>. Health problems associated with these issues include respiratory problems, depression, anxiety, neurological, cognitive, developmental, cardiovascular and behavioural conditions, cancers, poisoning and death<sup>1</sup>. Wales has a higher proportion of poor housing than England, with 29% and 22% having at least one major health hazard, respectively<sup>2</sup>. In addition to health and well-being problems of poor housing, there are financial costs to the individual and to society<sup>3</sup> in terms of associated higher crime, unemployment and health treatment costs<sup>2</sup>. Housing is a policy investment area in which the health system can contribute to reduce inequalities and a wider multi-agency approach to better population health<sup>3</sup>.

### Do housing interventions improve health?

Housing improvements can lead to improved health and well-being, but which types of interventions have the greatest benefits? Studies show that

warmth and energy efficiency improvements can lead to improvements in general, respiratory and mental health, less time off from school or work, increased use of the home for study and leisure, and improved relationships between household members<sup>1,4-9</sup>. Re-housing, retrofitting and neighbourhood renewal can lead to minor improvements in general and mental health.

### Is investing in housing a good use of money?

In 2011, it was estimated that the total cost to the NHS in Wales of dealing with category one hazards, which include unsafe stairs and steps, electrical hazards, damp and mould growth, excessive cold and overcrowding, was around £67 million per year<sup>3</sup>. The overall cost to society was estimated at around £168 million per year. These costs could be recuperated in nine years if investment was made to address the problems<sup>3</sup>. Economic evaluations show that some housing improvements, particularly warmth and energy efficiency, lead to more money back for each pound spent, i.e. a return on investment<sup>4</sup>. Although there is a need for more high quality intervention studies, the links between housing and health are well-established<sup>10</sup>.

- 1 Byrne E et al (2014) Housing and Health Evidence Review for Health Impact Assessment. <http://www.wales.nhs.uk/sites3/Documents/522/Evidence%20Review%20for%20Housing%20and%20HIA%20Final.pdf>
- 2 Davidson M et al (2011) The cost of poor housing in Wales. <http://www.sheltercymru.org.uk/wp-content/uploads/2013/05/BREnglishColour.pdf>
- 3 Thomson H et al (2009) The Health Impacts of Housing Improvement: A Systematic Review of Intervention Studies from 1887 to 2007. *American Journal of Public Health*, 99, 681-691.
- 4 Thomson et al (2007) The health impacts of housing-led regeneration: a prospective controlled study. *Journal of Epidemiology and Community Health*, 61, 211-214.
- 5 Thomson H and Petticrew M (2005) *Is housing improvement a potential health improvement strategy?* Geneva: World Health Organization.
- 6 Thomson H et al (2003) Health impact assessment of housing improvements: incorporating research evidence. *Journal of Epidemiology and Community Health*, 57, 11-16.
- 7 Douglas M et al (2003) *Health Impact Assessment of Housing Improvements: A Guide*. Glasgow: Public Health Institute of Scotland.
- 8 Thomson H et al (2002) Housing improvement and health gain: a summary and systematic review. Glasgow: MRC Social and Public Health Sciences Unit.
- 9 Thomson H et al (2001) Health effects of housing improvement: a systematic review of intervention studies. *British Medical Journal*, 323, 187-190.
- 10 Thomson H (2011) Housing improvements and their health effects. In: Braubach M et al. eds. *WHO environmental burden of disease associated with inadequate housing*, 179-195. Bonn: WHO European Office.

## Introduction to the health, social and well-being problems associated with poor housing

Housing presents a substantial policy investment area which, as part of a wider public health strategy, has the potential to improve population health and reduce inequalities<sup>4</sup>. A range of adverse physical and mental health outcomes have been linked to poor quality housing issues such as mould, warmth and energy inefficiency, infestations, second-hand smoke, overcrowding, noise, lack of green space and toxins<sup>1,2</sup> (lead, carbon monoxide, asbestos and radon). Health problems associated with these issues include respiratory problems, depression, anxiety, neurological, cognitive, developmental, cardiovascular and behavioural conditions, cancers, poisoning and death<sup>1</sup>.

Each year in the UK, an official estimate is made of how many more people die in the winter than at other times of the year, i.e. the number of Excess Winter Deaths (EWDs). EWDs are primarily due to illnesses brought on by the cold. In 2011, the World Health Organization<sup>11</sup> estimated that 30% of EWDs are due to cold homes, and could be prevented if people are kept warm during winter months. Recent figures for England and Wales predicted that over the last five winters there has been 142,447 EWDs<sup>12</sup>, of which around 42,734

Investment in housing in Wales can lead to improved health and well-being

were due to cold homes. Estimates for the winter of 2014/15 show the highest rate of EWDs and cold home deaths in over five years, with around 42,687 EWDs and around 12,806 the result of cold homes.

Wales has a higher proportion of poor housing than England, with 29% and 22% having at least one serious hazard, respectively<sup>2</sup>. Vulnerable groups such as the sick, elderly and unemployed are more likely to live in poor quality housing and spend more time indoors, exacerbating the negative health consequences of poor housing.

Given the established link between poor housing and ill health, investing in housing for prevention provides a cost-effective way of preventing ill health and reducing health inequalities.

11 Braubach M et al (2011) World Health Organization (WHO) report on environmental burden of disease associated with inadequate housing [http://www.euro.who.int/\\_\\_data/assets/pdf\\_file/0003/142077/e95004.pdf](http://www.euro.who.int/__data/assets/pdf_file/0003/142077/e95004.pdf)

12 Association for the Conservation of Energy (2015) Chilled to Death: The human cost of cold homes <http://www.energybillrevolution.org/wp-content/uploads/2015/04/ACE-and-EBR-factfile-2015-03-Chilled-to-Death.pdf>

## Overview of the costs to health and to wider society: the individual, the health system and the broader economy

In addition to health and well-being costs, there are individual level financial costs associated with poor housing<sup>3</sup>, for example a person may experience higher heating bills and may spend money trying to improve the symptoms of poor housing rather than addressing the root problem. Poor housing also poses costs to society in terms of crime, unemployment and health treatment<sup>2</sup>. A 2011 study estimated that the total cost to the NHS in Wales of dealing with category one hazards, which include unsafe stairs and steps, electrical hazards, damp and mould growth, excessive cold and overcrowding, was around £67 million per year<sup>3</sup>. The wider cost to society, including factors such as poor educational attainment and reduced life chances were estimated at £168 million a year. It was estimated that the total costs to society could be recuperated in nine years if investment was made to address the problems<sup>3</sup>.

The structural characteristics of a community have been linked to health and well-being outcomes<sup>13-15</sup>. Deteriorated or derelict neighbourhoods attract crime and antisocial behaviour<sup>16</sup>, whereas well-maintained and attractive communities with good quality housing, high levels of cleanliness, low housing density and close proximity to shopping facilities are more likely to have lower levels of crime<sup>17</sup>, be maintained with support from the community<sup>17</sup> and are associated with a higher quality of life<sup>8</sup>.



Neighbourhoods that are well-maintained are associated with less crime and antisocial behaviour

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- 13 Ellaway A and MacIntyre S (1998) Does housing tenure predict health in the UK because it exposes people to different levels of housing related hazards in the home or its surroundings? *Health and Place*, 4, 141-150.
- 14 Bernard P et al (2007). Health inequalities and place: a theoretical conception of neighborhood. *Social Science & Medicine*, 65, 1839-1852.
- 15 Fone D and Dunstan F (2006) Mental health, places and people: a multilevel analysis of economic inactivity and social deprivation. *Health and Place*, 12, 332-344.
- 16 Wilson JQ and Kelling GL (1982) Broken Windows. The Atlantic Online <http://www.lantm.lth.se/fileadmin/fastighetsvetenskap/utbildning/Fastighetsvaerderingssystem/BrokenWindowTheory.pdf>
- 17 Permentier M et al (2011) Determinants of Neighbourhood Satisfaction and Perception of Neighbourhood Reputation. *Urban Studies*, 48, 977-996.

## Overview of the effectiveness of prevention programmes and programme types that can reduce harms and problems

This structured evidence review provides an overview of the academic evidence on trials examining the impact of improvements to physical housing conditions on health outcomes. For further details on methodology, see Appendix One.

Table 1 provides an overview of the evidence from randomized controlled trials (RCTs) and prospective controlled studies (PCs) of housing interventions. It is clear that housing improvements can lead to improved health and well-being.

**This evidence review showed that following warmth and energy efficiency improvements, there are improvements to general, respiratory and mental health, less time off from school or work, and increased use of the home for study and leisure.**

There were also reports of increased privacy and improved relationships between household members. Three out of four studies in this brief review found improvements to general health, eight of eleven found improvements to respiratory health and three of five found improvements to mental health with half of studies finding improvements to existing illnesses or symptoms. When considering the effects of neighbourhood renewal or re-housing, some positive effects were found, but the evidence was less conclusive. It must be noted that due to some inconsistencies in findings, it is likely that the potential for health

improvements depends on baseline housing conditions and careful targeting of improvement activities in the most deprived communities. Housing that is of particularly poor quality at baseline is likely to yield the greatest health benefits after housing improvements.

Inconsistencies may also be a result of a short follow up period with potentially longer evaluation periods needed to determine the true health effects of housing interventions. Despite caveats, the evidence suggests that warmth and energy efficiency improvements in particular can lead to improved health outcomes.

While there were a number of studies other than RCTs and PCs that looked at the impact of housing improvement interventions on health (prospective uncontrolled studies, retrospective controlled or retrospective uncontrolled studies) these are not included in this brief review. However, additional evidence for the benefits of investing in housing comes from Health Impact Assessments (HIAs). HIA is part of a healthy public policy approach that is used to develop an understanding of the implications of housing strategies, plans, policies and projects on outcomes. Many of the potentially detrimental impacts of strategies, plans, policies and projects can be mitigated using a HIA. Recently, several housing HIAs have been completed in North Wales, Carmarthenshire<sup>18</sup> and Nottingham<sup>19</sup>, each highlighting the health and social benefits of investing in housing.

18 Morgan J et al (2012) Feeling Fine Healthier Homes: Carmarthenshire Health Impact Study.

19 Mutch AM et al (2010) Decent Homes Impact Study: The effects of Secure Warm Modern Homes in Nottingham. Nottingham City Homes: Knowledge Transfer Partnerships.

## Review of health economic and cost analyses of interventions

Public health interventions require public sector investment. Since money could be allocated to other healthcare activities, there is increasing emphasis placed on quantifying the cost-effectiveness of public health interventions<sup>20</sup>. Increasingly policy-makers, seeking to spend money from limited budgets, want evidence of value for money, and appropriately conducted

economic evaluations have the potential to identify such policies and interventions. There are four main types of economic evaluation: cost-benefits analysis (CBA), cost-effectiveness analysis (CEA), cost-utility analysis and cost-minimization analysis. Further information on each of these techniques is provided in Box 1.

### Box 1: A Brief Overview of Health Economic Measures

**Cost benefit analysis**, produces an output called the cost-benefits ratio. This is calculated by assigning financial values to the intervention and the outcomes of interest. The cost-benefits ratio gives an indication of return on investment (ROI) for every £ spent. For example, an intervention that saves £2.50 for every £1 spent would have a costs benefits ratio of 1:2.50, thus demonstrating a ROI. In contrast, although **cost-effectiveness analysis (CEA)** incorporates the costs of the intervention, it measures effectiveness in terms of units of health outcomes. The output of a CEA, the cost-effectiveness ratio, shows the cost of intervention associated with a unit of change. An intervention is considered more effective if the cost effectiveness ratio is low. For example, if there were two interventions that aimed to reduce asthma attacks with cost ratios of £20:1 or £85:1, the former would be considered the cost-effective option since every £20 spent

averts one asthma attack. Typically an effective and cost-effective intervention will have a cost-effectiveness ratio that states the intervention is less costly and more effective than its alternative, or compared to a threshold such as the National Institute for Health and Clinical Excellence (NICE) cost-effectiveness ratio of £20,000-£30,000.

**Cost-utility analysis** is a specific form of CEA that provides the cost of intervention for each quality adjusted life year (QALY). The output is the cost-utility ratio. **Cost-minimization analysis** compares alternative programs where all relevant outcome measures are equal (i.e., equal effectiveness or equal patient quality of life). Other types of financial evaluation which are not economic evaluations include cost-offset, cost-consequence analysis and social return on investment.

20 NICE (2009) Methods for the development of NICE public health guidance, 2nd edn. London: National Institute for Clinical Excellence.

This structured evidence review provides an overview of the academic evidence on economic analyses of housing improvement trials. For further details on methodology, see Appendix One. Table 2 shows studies that have performed some form of economic evaluation whilst table 3 shows studies that have carried out cost calculations without full economic evaluations.

Table 2 shows five studies that carried out an economic evaluation. Two performed CBA and found a Return on Investment (ROI) for interventions improving warmth and energy efficiency and reducing damp and mould. Three used CEA: no positive results were found using this type of analysis, perhaps due to differences in methodology. Financial economic evaluations of warmth and energy efficiency improvements showed that they led to a return on investment. Table 3, which shows studies that carried out cost calculations without economic evaluations, shows that warmth and energy efficiency improvements were associated with reduced fuel costs, reduced healthcare costs and a better financial situation. Studies on re-housing, retrofitting and neighbourhood were associated with an increase in rent, reduced fuel poverty, reduced household running costs, and reductions in the prescribing of drugs related to mental health illnesses. Although some of the evidence from cost and economic evaluations is mixed, there is some evidence suggesting a ROI for housing improvement interventions.

## Summary of the case for investing in prevention

The links between housing and health are well-established, providing a case for investing in housing for prevention of ill health<sup>13</sup>. The adverse health, well-being and social effects of poor housing are well documented<sup>1</sup>. In particular, improvements in warmth and energy efficiency can lead to tangible improvements to short-term health outcomes. This evidence is complemented by CBA, which shows a ROI for warmth and energy efficiency improvement interventions. Although some studies did not find positive effects of housing interventions, long-term health outcomes are difficult to assess given the short time-frame for evaluations. Housing improvements may yield positive benefits years after, even for the next generation.

Health benefits are more likely for individuals whose housing conditions are poor to begin with suggesting the need for carefully targeted interventions, which would provide a cost-effective mechanism for delivering interventions in times of austerity. It is important to invest in good quality housing to prevent the onset of illnesses<sup>4</sup> and to avoid costs incurred by individuals, the NHS and other public sector bodies and wider society.

Investment  
in housing  
improvements  
can lead to  
savings for the  
economy

## Broader housing policy issues for Wales

While a comprehensive review of housing policy in Wales is beyond the scope of this document, this section contains an overview of a number of policy initiatives in order to provide some context in which to interpret health and housing evidence. There are a number of grants and schemes available from the UK and Welsh Government, energy suppliers and local councils to improve warmth and energy efficiency in both privately owned and rented homes<sup>21</sup>. In Wales, support is available through the Nest Programme, Green Deal and Energy Companies Obligation (ECO). The Green Deal, available in England, Scotland and Wales, allows a person to make energy efficiency improvements without 'up front' costs. Instead, it is paid for by instalments in the electricity bill for a period of up to 25 years. The payments are agreed at the start and the loan stays with the property after the bill payer moves on. The loan can also be paid early, but penalty charges apply. The Green Deal is designed to ensure that the household does not pay out more than expected savings on the energy bill, however, this is not a guarantee and the actual costs may exceed the estimated savings, for example, if there is an increase in energy use or a fall in energy prices. Unlike some schemes where individuals only qualify if they receive certain means-tested or income-related benefits (such as income support, housing benefits, council tax benefits, disability, unemployment or pension related benefits), the Green Deal is not means tested. ECO, introduced alongside the Green Deal, aims to save carbon and get efficient boilers and insulation into the homes of vulnerable people across Great Britain. ECO is split into three elements: 'Affordable Warmth', which may provide free energy saving measures to low-income and vulnerable households; 'Carbon

Saving Obligation' to provide funding to insulate solid-walled properties (internal and external wall insulation) and those with 'hard to treat' cavity walls; and 'Carbon Saving Communities' to provide free insulation and glazing measures to people living in the bottom 15% of the UK's most deprived areas. It is expected that this part of ECO will particularly benefit people in social housing. Individuals qualify if they are on a low income and live in areas where the population size is below 10,000, i.e. small communities. This scheme will run until 2017.

In terms of the evaluation of housing policy measures, an example is taken from the Warm Homes Oldham (WHO) project<sup>22</sup>. The ongoing WHO project aims to alleviate fuel poverty by delivering home energy improvements and advice to people at risk of fuel poverty, or of poor health as a result of fuel poverty. Specifically, three forms of support are delivered including energy use advice, income maximization (for example, tariff switches; relieving fuel debt) and physical energy efficiency improvements using ECO grant funding (loft and cavity wall insulation; solid wall insulation; new boiler and heating controls). The interim evaluation, published in September 2014, examined pre- and post-intervention scores for self-reported health, wellbeing and energy use. Results showed improvements to general health and well-being, life satisfaction, condition of homes, and fuel poverty (84% agreed that they spent less on heating post-intervention and 75% were predicted to move out of fuel poverty). Although the results are positive, notably this study used a before and after design and did not include a comparison group, therefore results must be interpreted with caution.

21 Turn2us (2015) [http://www.turn2us.org.uk/information\\_\\_resources/benefits/housing\\_costs/water\\_and\\_energy/energy\\_efficiency\\_grants.aspx](http://www.turn2us.org.uk/information__resources/benefits/housing_costs/water_and_energy/energy_efficiency_grants.aspx)

22 Easdon W (2014) Warm Homes Oldham evaluation: interim report [http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=2&ved=0CCcQFjAB&url=http%3A%2F%2Fwww.oldham.gov.uk%2Fdownload%2Fdownloads%2Fid%2F3386%2Fwarm\\_homes\\_interim\\_evaluation\\_report&ei=sB0-VaqUBcvjalk0gJgN&usq=AFQjCNH03uo4noQ-rji9DiyILrfWMRsjw&bvm=bv.91665533,d.bGg](http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=2&ved=0CCcQFjAB&url=http%3A%2F%2Fwww.oldham.gov.uk%2Fdownload%2Fdownloads%2Fid%2F3386%2Fwarm_homes_interim_evaluation_report&ei=sB0-VaqUBcvjalk0gJgN&usq=AFQjCNH03uo4noQ-rji9DiyILrfWMRsjw&bvm=bv.91665533,d.bGg)

Consequently, this study also highlights the need for more well-controlled evaluations of policy interventions.

In terms of more general policy measures, the vision for the current strategy adopted by Welsh Government, 'Improving Lives and Communities', is to provide housing that is affordable and suitable for people in Wales (see Figure one).

The strategy calls upon banks, private landlords, developers and voluntary organisations to work with the Welsh Government. Key strategic

priorities include increasing the number and range of homes in Wales, improving services for people from minority groups and homeless people, improving the quality of social and private housing and making homes more energy efficient. The latter two priorities are particularly relevant when considering the current evidence around housing improvement interventions. Although not all initiatives are directly related to the interventions examined in this brief review, many will result in better quality housing, and potentially, benefits to health.

### Figure one: Interventions, schemes and programmes introduced by Welsh Government to implement 'Improving Lives and Communities'

#### Houses into Homes

A £20 million fund providing interest-free loans to owners of empty properties to bring them up to a standard so they can come back into use.

#### Help to buy

A Mortgage Guarantee scheme whereby the Government offers lenders the option to purchase a guarantee on mortgage loans for mortgages up to £600,000, running until December 2016.

#### Cooperative Housing

Cooperative housing is an alternate form of ownership of homes and property, in which the property is owned by an organisation and then sold as shares to the residents of the community. Cooperative housing splits costs on shared housing amenities. Around 500 additional co-operative homes will be established in Wales by 2016.

#### Housing Quality

The Welsh Housing Quality Standard<sup>23</sup> (WHQS) must be met by all Registered Social Landlords (RSLs) by 2020. A Ministerial Task Force is assisting landlords who are at risk of not meeting the standards.

#### Social Housing Grant

This is a grant given to RSLs (housing associations) by the Welsh Government. The grant aims to provide new affordable housing for rent or low cost home ownership. It allows local authorities to bring forward affordable housing schemes and helps with the purchase of land. An additional £29 million was made available in 2013.

#### New Revenue Grant for Social Housing

This grant is in development, and aims to provide £4 million per year for 30 years to enable RSLs to build new homes.

<sup>23</sup> Welsh Government (2013) Welsh Housing Quality Standard (WHQS) <http://gov.wales/docs/statistics/2013/131120-welsh-housing-quality-standard-31-march-2013-revised-en.pdf>

In terms of improving the quality of existing housing, 'Houses into Homes' and 'Welsh Housing Quality Standard' enable local authorities and property owners to restore housing to a healthy and safe standard, whereas the other interventions assist in the development and purchase of new housing, increasing affordability and increasing the rate of development of new housing.

The Well-being of Future Generations (Wales) Act 2015 does not legislate on housing. However, an accompanying Explanatory Memorandum highlights the importance of housing, stating "...the interplay and integration of different policies at all levels such as housing, transport ... can all make significant contributions to overall health and well-being, and help to reduce health inequalities." The report uses the provision of "Secure safe & warm housing through support for landlords and effective regulation" as an example of how an organisation can contribute to the achievement of the well-being goals.

Regeneration is another method of improving the quality of housing that involves an integrated set of activities aiming to reverse economic, social, environmental and physical decline to achieve long lasting improvement in areas where market forces alone will not do this without support from the Welsh Government. Regeneration strategies

in Wales include the 'Ambition Statement for Regeneration' (June 2010), the 'Framework for Regeneration Areas' (October 2010), and 'Vibrant and Viable Places: New Regeneration Framework' (2013). 'Vibrant and Viable Places' sets out the Welsh Government's priorities and action plans for regeneration, which focus on town centres, coastal communities and Communities First areas. Three objectives shape the framework – Prosperous Communities, Learning Communities and Healthier Communities.

The demand for good quality, affordable housing has increased rapidly, and in April 2010 there was a waiting list of around 80,000 households<sup>1</sup>. This demand cannot be satisfied with the current provision, and estimates suggest 14,000 new homes are needed each year for the next 15 years to rectify this deficit<sup>24</sup>. Housing is a policy area that is devolved from UK Government and Welsh Government has embarked on a large-scale programme of housing expansion including £400 million for 7,500 new affordable homes in Wales by 2016<sup>25</sup>, which will help rectify the deficit. New homes are built to a standard that is suitable for health, but restoring existing housing to a healthy and safe standard can compliment activities to reduce the housing deficit.

24 Holmans A and Monk S (2010) *Housing Need and Demand in Wales 2006-2026*. Merthyr Tydfil: Welsh Assembly Government [http://www.whnb.org.uk/uploads/media/100707housingdemandandneedfullen\\_full\\_report.pdf](http://www.whnb.org.uk/uploads/media/100707housingdemandandneedfullen_full_report.pdf)

25 Welsh Government (2013) *Homes for Wales – Housing (Wales) Bill*. <http://gov.wales/about/cabinet/cabinetstatements/2013/8207341/?lang=en>

**Table 1: Housing improvement studies and reported health impacts**

Author, year	Study type (study quality)	Change in housing condition	Time since intervention	General Health Impact; No of outcomes	Respiratory Health Impact; No of outcomes	Mental health Impact; No of Outcomes	Illness or symptoms Impact; No of Outcomes	Economic evaluation (see table 2; Y/N)	Costs data (see table 2; Y/N)
<b>Warmth and energy efficiency improvements (combined with other)</b>									
Woodfine et al 2011 (warmth improvements combined with enhanced ventilation) <sup>26</sup>	RCT (B)		12 months		Improvement (a)			<b>Y</b>	<b>N</b>
Osman et al 2010 <sup>27</sup>	RCT (A)	Improvement+	5 months		Negative health impact+	Negative health impact+			
Howden-Chapman et al 2007 <sup>28</sup>	RCT (A)	Improvement**	Less than 1 year	Improvement**; three outcomes	Improvement**; five outcomes	Improvement**; three outcomes		<b>Y</b>	<b>N</b>
Howden-Chapman et al 2008 <sup>29</sup>	RCT (A)	Improvement**	4 to 5 months	Improvement**	Improvement**; 11 outcomes		Unclear/mixed effects+; four outcomes	<b>N</b>	<b>Y</b>
Barton et al 2007 <sup>30</sup>	RCT (A)	Unclear/mixed effects**	Less than 2 years		Improvement+; seven outcomes		Unclear/mixed effects+; two outcomes	<b>Y</b>	<b>N</b>

26 Edwards RT et al (2011) Enhancing ventilation in homes of children with asthma. *British Journal of General Practice*, 61, 733-741.

27 Osman LM et al (2010) A randomized trial of home energy efficiency improvement in the homes of elderly COPD patients. *European Respiratory Journal*, 35, 303-309.

28 Howden-Chapman P et al (2007) Effect of insulating existing houses on health inequality: cluster randomised study in the community. *British Medical Journal*, 334, 460.

29 Howden-Chapman P et al (2008) Effects of improved home heating on asthma in community dwelling children: randomised controlled trial. *British Medical Journal*, 337, 1411.

30 Barton A et al, on behalf of the Torbay Healthy Housing Group (2007) The Watcombe Housing Study: the short term effect of improving housing conditions on the health of residents. *Journal of Epidemiology and Community Health*, 61, 771-777.

Author, year	Study type (study quality)	Change in housing condition	Time since intervention	General Health Impact; No of outcomes	Respiratory Health Impact; No of outcomes	Mental health Impact; No of Outcomes	Illness or symptoms Impact; No of Outcomes	Economic evaluation (see table 2; Y/N)	Costs data (see table 2; Y/N)
Braubach et al 2008 <sup>31</sup>	PC (A)	Improvement (a)	5 to 8 months	Improvement (a)	Improvement (a)	Improvement+		<b>NA</b>	<b>NA</b>
Platt et al 2007 <sup>32</sup>	PC (A)	Improvement**	1 to 2 years	Improvement**; two outcomes	Unclear/mixed effects+; two outcomes		Improvement**; two outcomes	<b>N</b>	<b>Y</b>
Lloyd et al 2008 <sup>33</sup>	PC (B)		1 to 1.5 years				Improvement**	<b>N</b>	<b>Y</b>
Shortt and Rugkasa 2007 <sup>34</sup>	PC (B)	Improvement**	1 to 3.5 years		Unclear/mixed effects+; three outcomes	Improvement+	Improvement**; three outcomes	<b>N</b>	<b>Y</b>
Eick et al 2004 <sup>35</sup>	RCT (C)	Unclear/mixed effects	4 to 12 months		Improvement** 2 outcomes; change in intervention group only			<b>N</b>	<b>Y</b>
Caldwell et al 2001 <sup>36</sup>	PC (C)	Improvement+	6 to 12 months		Improvement**		Unclear/mixed effects+; four outcomes	<b>N</b>	<b>Y</b>

PC – prospective controlled study; RCT – randomized-controlled trial; \*\*p<0.05; +p>0.05; a: no statistics/data available

31 Braubach et al (2008) Preliminary Results of The WHO Frankfurt Housing Intervention Project. Copenhagen, Denmark: World Health Organization.

32 Platt S et al (2007) The Scottish Executive Central Heating Programme: assessing impacts on health. Edinburgh, Scotland: Social Research Development Dept, Scottish Executive.

33 Lloyd EL et al (2008) The effect of improving the thermal quality of cold housing on blood pressure and general health: a research note. *Journal of Epidemiology and Community Health*, 62, 793–797.

34 Shortt N and Rugkasa J (2007) “The walls were so damp and cold”: fuel poverty and ill health in Northern Ireland: results from a housing intervention. *Health and Place*, 13, 99–110.

35 Eick SA et al (2004) The Breath of Fresh Air Project: Draft Report for Comments September 2004. Plymouth, England: AC & T England Ltd.

36 Caldwell J et al (2001) Glasgow Warm Homes Study: Final Report. Glasgow, Scotland: Glasgow City Council Housing Services.

Author, year	Study type (study quality)	Change in housing condition	Time since intervention	General Health Impact; No of outcomes	Respiratory Health Impact; No of outcomes	Mental health Impact; No of Outcomes	Illness or symptoms Impact; No of Outcomes	Economic evaluation (see table 2; Y/N)	Costs data (see table 2; Y/N)
<b>Rehousing or retrofitting with or without neighbourhood renewal</b>									
Kearns and Petticrew 2008 <sup>37</sup>	PC (A)	Improvement**	24 months	Improvement+	Deterioration+	Improvement+; four outcomes	Unclear/mixed effects+; three outcomes	<b>NA</b>	<b>NA</b>
Thomson et al 2007 <sup>38</sup>	PC (A)	Improvement**	12 months	Improvement+; two outcomes		Unclear/mixed effects+		<b>N</b>	<b>Y</b>
Critchley et al 2004 <sup>39</sup>	PC (A)	Improvement (a)	1 to 12 months	Unclear/mixed effects (a)		Unclear/mixed effects (a)		<b>N</b>	<b>Y</b>
Thomas et al 2005 <sup>40</sup>	PC (B)		22 months			Unclear/mixed effects**		<b>N</b>	<b>Y</b>
Barnes 2003 <sup>41</sup>	PC (B)	Unclear/mixed effects**	18 months	Improvement+; four outcomes		Improvement+	Improvement+	<b>NA</b>	<b>NA</b>
Evans and Layzell 2000 <sup>42</sup>	PC (B)	Unclear (a)	8 to 18 months					<b>NA</b>	<b>NA</b>

PC – prospective controlled study; RCT – randomized-controlled trial; \*\*p<0.05; +p>0.05; a: no statistics/data available

37 Kearns A and Petticrew M (2008) SHARP Survey Findings: Physical Health and Health Behaviour. Glasgow, Scotland: Dept of Urban Studies, University of Glasgow and MRC Social & Public Health Sciences Unit.

38 Thomson H et al (2007) The health impacts of housing-led regeneration: a prospective controlled study. *Journal of Epidemiology and Community Health*, 61, 211–214.

39 Critchley R et al (2004) Housing investment and health in Liverpool. Sheffield: CRESR, Sheffield Hallam University.

40 Thomas R et al (2005) Housing improvement and self-reported mental distress among council estate residents. *Social Science and Medicine*, 60, 2773–2783.

41 Barnes R (2003) Housing and health uncovered. London, England: Shepherds Bush Housing Association. Available at: [http://www.housinglin.org.uk/\\_library/Resources/Housing/Housing\\_advice/Housing\\_\\_Health\\_Uncovered.pdf](http://www.housinglin.org.uk/_library/Resources/Housing/Housing_advice/Housing__Health_Uncovered.pdf)

42 Evans M and Layzell J (2000) The Effect of Housing Renewal on Health: The Riverside Project (End of Grant Report). Cardiff: University of Wales Colleges of Medicine.

**Table 2: Housing improvement studies reporting an economic evaluation (either cost-benefit analysis (CBA) or cost-effectiveness analysis (CEA))**

Author, date, country	Study type and description	Type of economic evaluation	Economic data results (costs and benefits)
Edwards et al 2011 UK <sup>27</sup>	RCT involving warmth improvements combined with ventilation	CEA	£234 per unit change in PedsQL asthma-specific quality of life scale
Barton et al 2007 UK <sup>31</sup>	RCT involving warmth and energy efficiency improvements	CEA	No significant difference between intervention and control on SF-36 scores: intervention more costly and less-effective than status quo.
Howden-Chapman et al 2007 New Zealand <sup>29</sup>	RCT involving ceiling insulation, draught-proofing windows and doors and insulation type improvements to floors	In-house' CBA (NZ \$)	Cost benefits ratio: 1:1.87
Lawson et al 2013 UK <sup>43</sup>	PC transferring social and private tenants to new-build social housing in the Scottish Housing Regeneration Project	CEA/CUA	Average change in health utility scores attributable to intervention were +0.001 for all households, +0.001 for family households, -0.04 for adult households and -0.03 for elderly households. No significant effects were reported
Mackenzie et al 2002 UK <sup>44</sup>	PC study to improve heating and reduce damp and mould	'In-house' CBA (GB £)	Net annual benefits (benefits – costs): £413.33

\*\*CBA – cost-benefits analysis; CEA – cost-effectiveness analysis; CUA - cost-utility analysis; SF-36 - Short-Form 36 Health Survey; RCT – randomized controlled trial; PC – prospective controlled study; UK – United Kingdom; PedsQL – Pediatric Quality of Life Inventory

43 Lawson KD et al (2013) Investing in health: is social housing value for money? A cost-utility analysis. *Journal of Epidemiology and Community Health*, 67, 829-834.

44 Mackenzie IF et al (2002) Housing & Health Paper 2: A health economic study to estimate the costs and benefits of the use of NHS funds to install heating in the houses of children with asthma. Housing & Health – the Cornwall intervention study: a report to the trustees of EAGA charitable trust. St Austell: Cornwall and Isles of Scilly Health Authority.

**Table 3: Housing improvement studies reporting cost data without economic evaluation**

Author, date, country	Study type and description	Intervention costs	Recipient costs	Potential for economic evaluation	Results/costs reported
<b>Studies of warmth and energy efficiency improvements</b>					
Howden-Chapman et al 2008 New Zealand <sup>29</sup>	RCT	<b>X</b>		<b>X</b>	Mean cost of intervention per house (NZ)\$3000
Heyman et al 2011 UK <sup>45</sup>	RCT	<b>X</b>		<b>X</b> (SF-36; QALY)	Mean cost of intervention per house £727
Eick et al 2004 UK <sup>35</sup>	RCT	<b>X</b>	<b>X</b>		Costs of intervention £2500 per house; changes in health costs three months after intervention minus £6557.78 (including GP visits -£136, GP home visits -£22.58, outpatient visits -£220, hospital admissions -£5740, steroids -£5.70, antibiotics -£16.80, nebuliser -£1.23, absence from school due to asthma -£478.42; absence from school due to other reasons £62.95)
Platt et al 2007 UK <sup>33</sup>	PC	<b>X</b>			Those in receipt of improved heating were significantly less likely to report difficulties to manage financially than those who did not acquire heating
Lloyd et al 2008 UK <sup>33</sup>	PC		<b>X</b>		Maximum heating costs per week per house vs average heating cost per week four years after the intervention
Shortt and Rugkasa 2007 UK <sup>34</sup>	PC		<b>X</b>		Mean fuel costs per annum before and after: £1113 vs £752
Warm Front Study Group 2006 UK <sup>46</sup>	PC	<b>X</b>	<b>X</b>	<b>X</b>	Maximum grant value of £2500 per house; following intervention fuel consumption reduced by between 10-17%. Gas central heating did not change fuel consumption
Caldwell et al 2001 UK <sup>36</sup>	PC		<b>X</b>		Self-reported changes in annual energy costs in four intervention sites: mean per house = minus £288.56; no change reported in control

45 Heyman B et al (2011) The National Energy Action Research Group: A Randomised Controlled Trial of an Energy Efficiency Intervention for Families Living in Fuel Poverty. *Housing Studies*, 26, 117–132.

46 The Warm Front Study Group (2006) Health impact evaluation of England's home energy efficiency scheme (Warm Front). Headline results. Report to Energy Saving Trust/Defra.

Author, date, country	Study type and description	Intervention costs	Recipient costs	Potential for economic evaluation	Results/costs reported
<b>Rehousing/retrofitting and/or neighbourhood renewal</b>					
Thomson et al 2007 UK <sup>38</sup>	PC		<b>X</b>		Mean change in rent per week intervention/control = £6.65 vs £1.31
Critchley et al 2004 UK <sup>39</sup>	PC		<b>X</b>		Liverpool housing renewal project (£260 million in total for this and other interventions); estimated annual running costs before and after re-housing intervention for two person household: £662 vs £347; single person household: £610 vs £319. Percentage living in fuel poverty before and after intervention for two person household: 48% vs 8%; one person household: 86% vs 14%
Thomas et al 2005 UK <sup>40</sup>	PC	<b>X</b>		<b>X</b>	£2 million over study period (regeneration project including projects other than housing)
Walker and Bradshaw 1999 UK <sup>47</sup>	PC (using area level cross sectional data at both time points)	<b>X</b>	<b>X</b>		Investment of £8.6 million by local authority for the repair of homes and renovation of property. Percentage change in GP prescribing costs per 1000 patients four years after intervention for Practice A / Practice B / controls were as follows: gastrointestinal: 12.3% /25.8% /12.9%; cardiovascular: 31.3% /37.5% /27.0%; respiratory: 46.9%/ 82.9%/ 43.6%; central nervous system: 79.2% /73.7% /79.7%; hypnotic: 67.6% /16.0%/93.3%; anxiolytic: -74.1% /-12.3%/ -6.5%; antidepressant: 109.5% /86.3% /120.8%; analgesic: 26.2% /26.6% /42.7%; anti-infective: 13.0% /-22.19% /-26.3%.

PC – prospective controlled study; RCT – randomized-controlled trial; SF-36 – Short-Form 36 Health Survey; QALY – Quality Adjusted Life Year

47 Walker R and Bradshaw N (1999) The Oakdale renewal scheme: use of prescribing data to assess the impact on the health of residents. Gwent Health Authority & Welsh School of Pharmacy.

## Appendix One

### Methodology for effectiveness studies

#### Aim:

This section aimed to provide a structured evidence review of the academic evidence on trials examining the impact of improvements to physical housing conditions on health outcomes.

#### Search Strategy:

Medline, PubMed, PsychInfo and Google Scholar were searched for academic reviews using the following search terms: 'housing', 'health', 'housing improvement/s', 'housing intervention/s', 'meta-analysis', 'systematic review', 'qualitative review', 'review'. We identified a 2009 systematic review<sup>3</sup> incorporating trials published up until 2007, which examined the impact of housing improvement intervention studies on health outcomes. For the purposes of the current evidence review, the original 2009 review was used as a basis on which to draw on the scientific evidence and was updated with trials published up until December 2014. Additional trials were identified using the search criteria outlined in the original paper<sup>3</sup> and by forward and backwards reference searching, and include Woodfine et al<sup>26</sup>, Osman et al<sup>27</sup> and Lloyd et al<sup>33</sup>).

#### Inclusion and Exclusion Criteria:

Studies were included in this evidence review if they involved enhancement to the physical structure of housing, including warmth and energy efficiency. Studies were excluded if they involved improvements to mobile homes, psychosocial or educational interventions, interventions to reduce exposure to lead, radon, or allergens, modifications for medical reasons, accident prevention, air quality improvement, and interventions to increase disabled occupants' mobility. Studies in English from any

country were included if they had a randomized controlled- or prospective controlled design.

#### Study Quality, Data Extraction, and Intervention Integrity:

Studies were screened for quality in the original 2009 review using an existing critical appraisal tool developed for use in assessing quasi-experimental studies in public health<sup>48</sup>; newer literature included in the current document were screened and appraised by SL based on the framework used in the original review. Studies were assessed for six potential sources of bias: sample selection, study design, control for confounding, blinding of participants and assessors, data collection (sources and methods), and withdrawals. A summary grade (A, B, or C) was assigned to each study. In addition to the extraction of health outcomes, other extractions included the intervention type, length, population, and whether or not an economic- or cost-evaluation was conducted (see Table 1).

#### Data Synthesis:

Studies were grouped into two intervention types: improvements in warmth and energy, and rehousing or retrofitting with or without wider neighbourhood renewal. The health outcomes were grouped in to four categories: general health, respiratory health, mental health, and illness or symptoms. These categories are presented in Table 1 along with the direction of the impact (negative, positive, none, or unclear) and the level of statistical significance ( $P < .05$ ). Where more than one outcome was reported for one category, the overall impact was indicated. Data were synthesized narratively.

48 Thomas H. Quality assessment tool for quantitative studies. Effective Public Health Practice Project, Hamilton, Canada. Available at: <http://www.ehphp.ca/tools.html>

## Methodology for cost-effectiveness studies

### Aim:

The aim of this structured evidence review was to provide an overview of the academic evidence on economic analyses of housing improvement studies and health outcomes.

### Search Strategy:

Medline, PubMed, PsychInfo and Google Scholar were searched for academic reviews using the following search terms: 'housing', 'health', 'housing improvement/s', 'housing intervention/s', 'economic evaluation', 'cost evaluation', 'cost-effectiveness analysis', 'cost-benefit analysis', 'cost-utility analysis', 'cost-minimization analysis', 'meta-analysis', 'systematic review', 'qualitative review', 'review'. A 2013 systematic review was identified<sup>49</sup>, which examined economic analyses of housing improvement interventions and health outcomes. The 2013 review searched 45 medical and social science databases, websites and grey literature to identify studies. For the purposes of the current evidence review, the 2013 review was used as a basis on which to draw on the scientific evidence. To identify economic evaluations published after 2013, an additional search was performed using the search criteria outlined in the 2009 effectiveness review<sup>3</sup> and using forward and backwards reference searching, and include Edwards et al<sup>27</sup> and Lawson et al<sup>45</sup>.

### Inclusion and Exclusion Criteria:

The inclusion and exclusion criteria were identical to those described in the effectiveness review. Randomized controlled trials or prospective controlled studies that conducted a full economic- or cost-evaluation were included. Housing intervention studies included in the 2009 systematic review of the health impacts of housing improvement<sup>3</sup> were examined for reports of costs and economic analyses. Further details of the scope of the review (inclusion and exclusion criteria), and evidence appraisal are available in the 2009 paper<sup>3</sup>.

### Study Quality, Data Extraction, and Intervention Integrity:

Study quality and intervention integrity was assessed using the same criteria adopted in the effectiveness review<sup>3</sup>.

### Data Synthesis:

Cost data were tabulated alongside a summary of reported health impacts. Studies were allocated into one of two groups based on the type of data reported: studies that reported having undertaken an economic evaluation are presented in Table 2 along with study type and a description of the intervention, the type of economic evaluation, and results of the economic evaluation; studies that presented cost data without economic evaluation are presented in Table 3 along with an indication of the type of costs included in the analyses, whether or not there was potential for economic evaluation, and results.

49 Fenwick E et al (2013) Economic analysis of the health impacts of housing improvement studies: a systematic review. *Journal of Epidemiology and Community Health*, 67, 1-11.