SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Combat Poverty Agency working for a poverty-free Ireland

Effectiveness of Domestic Energy-Efficiency Programmes

Fuel Poverty Action Research Report 4: Comfort and Indoor Temperature Impacts

social market research SMR

Published by:

Social Inclusion Division
Department of Social and Family Affairs

ISBN: 978 0 9563903 6 3

December 2009

Acknowledgements

This study was initiated by the Combat Poverty Agency in collaboration with The Sustainable Energy Authority of Ireland. Since July 2009 the Combat Poverty Agency has been integrated with the Office for Social Inclusion into the new Social Inclusion Division within the Department of Family and Social Affairs.

The Department of Social and Family Affairs would like to thank all those who have been involved in the project since its inception, in particular those involved in various advisory groups; staff in the Combat Poverty Agency, the Social Inclusion Division, and The Sustainable Energy Authority of Ireland; and those involved in conducting the fieldwork for the study, Northside Community Enterprises Ltd. (NCE) in Cork and Meitheal Forbarth na Gaeltachta (MFG) in Donegal. Their efforts are greatly appreciated.

The Department of Social and Family Affairs is pleased to publish this timely and important set of reports evaluating the impact of the Warmer Homes Schemes for low-income households.

The author would like to acknowledge the contributions of the following:

Ruth Buggie, Sustainable Energy Ireland
Kevin O'Rourke, Sustainable Energy Ireland
Áine Ní Láimhín, Meitheal Forbartha na Gaeltachta
Benny Swinburne, Department of Social and Family Affairs
Geraldine Delorey, Health Service Executive
Graham Craig, Department of the Environment, Heritage and Local Government
John O'Leary, Northside Community Enterprises Ltd
Jonathan Healy, formerly Combat Poverty Agency
Jorun Rugkasa, Institute of Public Health
Karen Byrne, Department of Social and Family Affairs
Liam Johnston, Department of the Environment, Heritage and Local Government
Michael Culloty, Money Advice and Budgeting Service
Sandra Coughlan, Health Service Executive
Sheila MacEvilly, formerly Health Service Executive
Shirley O'Shea, Health Service Executive
Eileen Gernon, St Vincent De Paul
Michael Martin, Sustainable Energy Ireland
Majella Kelleher, Sustainable Energy Ireland
Tom Halpin, Sustainable Energy Ireland
Jim Walsh, Department of Social and Family Affairs
Kasey Treadwell Shine, Department of Social and Family Affairs
Helen McAvoy, Institute of Public Health
Deirdre Mahony, Department of the Environment, Heritage and Local Government
Stjohn O'Connor, Department of Communications, Energy and Natural Resources
Déaglán Ó Dónaill, ESB
Catherine Hazlett, Department of Social and Family Affairs
Seán Lyons, Economic and Social Research Institute
Christine Liddell, University of Ulster

Contents

Context and Rationale 9

Literature Review 13

Findings 17

References 29

Appendix 31

Context and Rationale

Despite an extensive literature in the UK and an increasing awareness of the issue, research into fuel poverty and domestic energy efficiency remains relatively scarce in Ireland. This is particularly the case for ex post analysis of domestic energy-efficiency programmes aimed at reducing fuel poverty among low-income households. To address this gap, Combat Poverty and Sustainable Energy Ireland developed a fuel poverty action research project to inform public policy on the merits of domestic energy-efficiency programmes. A particular focus of this project was to assess the extent of improvements to household comfort and indoor temperature brought about the SEI-administered 'Warmer Homes Scheme' which retrofits private homes with insulation and other energy-saving measures. The study was set in Cork City and County Donegal.

Scope of the Study

This report examines the comfort and amenity aspects of fuel poverty as defined by Boardman (1991) and in particular it focuses on the links between comfort and temperature, energy-efficient housing stock and the impact of energy efficiency measures aimed at addressing comfort and temperature issues to alleviate particular aspects of fuel poverty.

Given the resource available, the study is based on a relatively small sample of 600 households – 247 households who had energy-efficiency measures installed under the Warmer Homes Scheme and a comparison group of 353 households who were not included in the initiative. It is important to state that the research has not been operationalised as a 'case control' study given the problems in matching households on specific criteria.

The study is set in a community development context, with local organisations in Cork City (Northside Community Enterprises Ltd) and County Donegal (Meitheal Forbartha na Gaeltachta) contributing to study design and implementation, including the conduct of all survey fieldwork on the study. Involving local communities in implementing the study was an important element of the implementation process, with these communities provided with an opportunity to further develop and build social value and capacity within their respective areas.

Fuel Poverty in Ireland

Boardman (1991) defines fuel poverty as 'the inability to heat one's home to an adequate (i.e. safe and comfortable) level owing to low household income and poor, energy inefficient housing and also the need to spend greater than 10 per cent of household income on fuel to achieve an acceptable level of comfort and amenity'. This definition is commonly accepted and reflects the close relationship between low household income, poor energy efficiency and household comfort. Applying this expenditure method of measuring fuel poverty, research by the ESRI (2008) estimated that 19 per cent of Irish households (301,368) may have experienced fuel poverty in 2008. Fuel poverty can also be measured using self-reported subjective measures such as being able to heat one's home to a temperature that is comfortable in winter. Again using this measure the ESRI (ibid) estimated that 3.6 per cent of Irish households (56,047) had experienced fuel poverty in 2007.[1]

[1] *Note that these figures are estimates given that data on fuel poverty are not routinely collected by government in Ireland.*

The Policy Response to Fuel Poverty

It is commonly recognised that three main factors influence the level of fuel poverty: fuel prices, household income, and energy efficiency of the housing stock. The relative importance of each factor depends on the period being examined, but by way of an example, the Scottish Executive reported that between 1996 and 2002 the reduction in fuel poverty was mainly attributable to increases in household income (50 per cent) and decreasing fuel prices (35 per cent), with energy-efficiency improvements playing a lesser role (15 per cent).

At a policy level, there is strong evidence of an increased government commitment to tackling fuel poverty which is reflected in a number of key policy documents including the National Action Plan for Social Inclusion (2007-2016), the Government White Paper Delivering s Sustainable Energy Future for Ireland (2007-2020), the National Energy Efficiency Action Plan (NEEAP) 2009-2020 and the Programme for Government. Specifically in relation to the Warmer Homes Scheme there has been an increased budget allocation to the initiative year-on-year since its commencement in 2000.

In acknowledging that fuel poverty has significant impacts on the lives of people affected (e.g. thermal comfort, health status, quality of life etc), and a disproportionate impact on low-income households, SEI set up a Low Income Housing Programme to help establish and implement a national plan of action to systematically address the problem of fuel poverty. The Programme is based on the premise that low-income households are unable to afford the capital investment measures to improve the energy quality of their homes. Allied to this point SEI acknowledges that 'income supports and fuel allowances do not address this structural deficiency in this part of the housing stock'. To address these concerns the Warmer Homes Scheme was developed and implemented.

The Warmer Homes Scheme

The Warmer Homes Scheme was set up as the core delivery vehicle for addressing fuel poverty within low-income households. The core aim of the scheme is:

> *... to improve the energy efficiency and comfort conditions of homes occupied by low-income households, and to establish the systems and growing the capacity in Ireland to install such measures.*

The scheme is implemented through a social employment model, with regional community-based organisations appointed to carry out remedial works which includes: attic insulation, draught proofing, lagging jackets, energy-efficient lighting, cavity wall insulation and energy advice. Eligible homes are identified locally via networks drawn from the statutory and voluntary sectors. The scheme is directed at privately owned and rented homes, which are more diverse and difficult to access than local authority homes, with the latter catered for elsewhere. The scale of activity each year is dependent upon available funding and is targeted at specific geographical areas. By 2008, €10.93m had been allocated to the scheme, which covered interventions in 17,662 households (source: Sustainable Energy Ireland).

Linking the Warmer Homes Scheme with the Study

The Warmer Homes Scheme was identified as an appropriate vehicle for identifying households to take part in the study. Given that community-based organisations had already been contracted to retrofit households as part of the Warmer Homes Scheme, it was agreed that involving these same organisations would be an efficient way of implementing the study because of the close association between the organisations and the local community (i.e. established credibility, local contacts, mitigating problems associated with accessibility etc).

Literature Review

Thermal Comfort, Health and Poor Housing

The link between thermal comfort, ill-health and poor quality housing is well established, with people living in fuel poverty frequently living in cold, damp and thermally inefficient houses (Energy Research Group & Environmental Institute, 1999). For example, Byrne et al (1993) conclude that within the UK '... health improvements in Britain over the past 100 years have resulted far more from collective intervention in the environment than from the development, or even provision, of curative health care', with improvements in housing in particular associated with a broad range of health improvements.

This current study is consistent with a public health approach to addressing problems associated with poor housing, thermal comfort and ill-health, with causal systems seen as being responsible rather than single causal factors. The research focuses on the impact of a range of causal factors on health status (i.e. the study attempts to assess the impact of installing a range of energy efficiency measures on the health status of households), rather than attempting to identify a single cause of an illness and then eliminate that cause. A key determinant of health status is the thermal comfort of households.

The Centre for Sustainable Energy (CSE) in the UK (2009) states that the two approaches outlined requires the application of different methodologies for investigating the link between housing and health. Whereas the medical model tends to emphasise individual behaviour as the main cause of ill-health, a public health approach places more emphasis on what Acheson (1999) calls 'general susceptibility' which is based on the premise that people are vulnerable to a variety of ills because of health inequalities brought about through the economic and social environment in which they live.

In pointing to the causes of fuel poverty, the NEA (2009) identified a number of factors (e.g. low household income, prohibitive energy costs, inadequate thermal insulation and inefficient and uneconomic heating systems), although it concluded that energy efficiency is the 'only rational solution to fuel poverty'.

Defining Thermal Comfort

Healy (2004) posits that 'many physiological, psychological and environmental variables play a part in humans' perception of thermal comfort', and that it is possible to use indoor temperature as a gauge to thermal comfort. Collins (1985) states that a temperature of 18-24°C 'poses little threat to sedentary healthy people adequately clothed'. The Building Research Establishment (BRE,1985) considers 18-21°C as a comfortable temperature, whereas the UK Government recommends 21°C as an adequate level for living rooms, with 18°C recommended for other areas (DEFRA, 1999). The World Health Organisation (1987) recommends 18°C, with an increase of between 2 and 3 degrees for those vulnerable to the effects of cold strain (i.e. the elderly, the young etc). Healy's study uses the WHO's lower bound benchmark of 18°C for thermal comfort for those aged under 65 with the benchmark of 20°C or more for those aged 65 or older.

Low Internal Temperatures

In Ireland in 2005 there were 1950 extra deaths in the winter months compared with the summer months (Institute of Public Health, 2009). Excess winter mortality is relatively higher among older people and low-income groups, with the decline in UK winter mortality between 1977 and 1994 attributed to both the growth of central heating and improved health care (Wilkinson et al, 1998).

The close association between changes in temperature and excess winter deaths has been estimated by Alderson (1985) who found that in the UK 'for every degree change in the average winter temperature there is a rise or fall in the number of winter deaths by about 8,000'.

Curwen (1991) estimated that a third of 'excess winter deaths' is attributable to respiratory disease, with over half attributable to cardiovascular disease (mainly heart attacks and strokes). A key risk factor is blood pressure which increases significantly after 2 hours exposure to temperatures below 12°C, and most notably among older people (Collins et al, 1985).

Although there is widespread agreement in the literature that temperature is the key causal factor explaining excess winter deaths (Alderson, ibid), there is less consensus on the influence of internal house temperatures and external temperatures. In relation to external household temperatures the concern is that people do not use adequate clothing in cold weather (Keatinge, 1986). From a policy perspective, therefore, should the focus be on internal temperatures as the main determinant of excess winter deaths (in which case there would be significant implications in relation to heating, insulation or building standards), or should there be more emphasis on prevention by changing individual behaviour?

The literature suggests that both factors are relevant. The Eurowinter (1997) study of excess winter deaths examines the variations in winter death rates between different countries and concludes that differences can be explained by colder countries possibly having better thermal efficiency standards within their housing stock.

Collins' study concludes that although it is widely accepted that cold, damp housing is unhealthy, the relative effects of cold, damp and mouldy living conditions are difficult to disentangle as they are correlated. Collins posits that there is a greater increase in winter mortality from respiratory disease than from circulatory, with respiratory health more related to indoor temperatures and circulatory more related to outdoor cold. However, the CSE contends that it is '… very difficult to show a definitive link between home temperatures and specific health outcomes, just as it is nearly impossible to identify the exact thermal conditions of the home after someone has died'.

Goodwin (2000), in a review of the evidence linking cold temperatures and circulatory disease, suggests a link between internal temperatures and cold external temperatures in the form of what is termed 'cold stress' which arises when the strain of a cold morning might cause too much cardiovascular strain, particularly if leaving a cold dwelling. Goodwin posits that the effect of 'cold stress' might be lessened through warmer indoor temperatures, i.e. older people would be less susceptible to 'cold stress', and less at risk of circulatory disease, if they lived in a warmer home.

Another measure of the thermal comfort of homes is self-reported 'indoor cold strain'. Healy (ibid) contends that shivering is a useful physiological measure indicating that the body is not adequately protected from a cold environment. Collins et al have found that shivering, although relatively harmless among the young, can have adverse health effects in older people, leading to cardiovascular strain and potentially more serious health conditions such as hypothermia and pneumonia.

Relationship between Home Temperatures and Health Impact

Energy Action Scotland (1998) and Raw et al (2001) developed a set of guidelines in relation to household temperature and health impacts:[2]

- 21°C is a comfortable temperature for the population including older people
- 18°C is defined as a 'minimum temperature for population as a whole – little health risk although older and sedentary people may feel cold'
- Between 16°C and 12°C '… respiratory problems become more common with some cardiovascular risk'
- Exposure to temperatures between 12°C and 9°C for more than two hours causes core body temperatures to drop, blood pressure to rise and increased risk of cardiovascular strain
- Finally, temperatures of 5°C or less lead to a 'significant increase in the risk of hypothermia'.

Damp and Mould

Low levels of thermal comfort in households produce conditions where damp and mould can become commonplace. The association between dampness and ill-health has been well documented, with viruses which give rise to infections more common in damp houses (Hatch et al, 1979). Conversely there is research evidence to suggest that a certain level of damp may be beneficial, with upper respiratory tract illnesses increasing when relative indoor humidity is low (Henwood, 1997; Raw and Hamilton, 1995).

The research evidence from the UK suggests that the negative effects on health are associated with high rather than low levels of humidity. Hunt (1993) has documented the association between high levels of humidity and mould and dust mites. Mould growth is less common in homes that have a range of energy efficiency measures installed such as insulation, cavity walls, good ventilation, air circulation and good heating systems (Raw et al, 2001).

Mould is linked with a range of allergies, infections, toxic reactions, some cancers and psychological symptoms. Mould spores require a relative humidity of 70 per cent or more to grow. A study by Platt (1993) provided evidence that damp and mould do have an adverse impact on health, with the level of illnesses positively associated with increasing severity of dampness (dose response relation). Symptoms typically include nausea, breathlessness, backache, fainting and bad nerves among adults and respiratory symptoms (wheeze, sore

2 The levels are not absolute – people vary widely in their needs. It should not be assumed that ill health will inevitably result from failure to meet these criteria. The recommended levels are set on the basis that meeting them will normally protect against the adverse health effects of cold indoor conditions.

throat, runny nose), headaches, fever and vomiting among children. Platt found that these effects were independent of income, smoking, unemployment, cooking and washing facilities or the presence of pets.

It is also likely that cold, damp housing has some impact on mental health status, although the CSE points to the difficulty in trying to disentangle the detrimental effect of this factor from general deprivation. A study by Khamano (quoted by the Centre for Sustainable Energy, 2009) found that poor housing does lead to depression, particularly due to worries about fuel bills and feelings of 'helplessness' about being unable to improve one's housing. Henwood (1997) refers to research evidence showing the positive link between improved housing on psychological distress, whereas Raw et al (2001) point to the psychological distress suffered by the physical presence of fungal growth, the sometimes unpleasant smell and the difficulty of getting rid of mould. Raw et al also refer to the stigma associated with the presence of mould growth in one's home which can cause depression and stress.

Dust mites have been identified as a major contributor to asthma (Raw et al, 2001), due to their ability to trigger Type I allergic reactions. Dust mites thrive in conditions of 40 per cent or more humidity and at temperatures of between 17°C and 32°C (CSE). It is not clear what proportion of asthma in Ireland is partly or wholly attributable to dust mites. However, using Raw's conservative estimate of less than 5 per cent additional cases caused by dust mites could represent a substantial burden of disease, because asthma is one of the most common chronic conditions. Raw contends that 'even a weak causal link could thus generate many thousands of extra cases'.

Other research also points to an association between the presence of dust mites and other health conditions such as perennial rhinitis and eczema (Carswell and Thompson, 1987; Howarth et al, 1897), with the Howarth study reporting that the severity of atopic eczema could be greatly reduced by effective dust mite avoidance and that the association may be causal.

In relation to energy efficiency interventions there is growing concern (Howieson) that some aspects, such as central heating and insulation measures, might be exacerbating the problems associated with dust mites, given that these measures tend to produce more humidity unless they are accompanied by sufficient ventilation measures. Indeed a Scottish study by Energy Action Scotland (1998) found some evidence that asthma rates are lower in cold and draughty homes. Conversely, a study in Cornwall (Somerville, 2000) found that asthma rates declined among asthmatic children following the installation of central heating.

Data Collected

To evaluate the impact of the various programme interventions on the thermal comfort and indoor temperatures a range of data was collected at the household level (i.e. data on indoor temperature; awareness of the most appropriate room temperature; affordability of heating the home; shivering from cold in winter; and installation of energy efficiency measures).

Findings

The literature clearly indicates a close association between fuel poverty and ill health. Given that the questionnaire did not capture household net income, a number of subjective measures was used to establish the impact, if any, of the installation of energy efficiency measures on the level of fuel poverty.

Using the fuel poverty indicator of being able to afford to heat one's home in winter to a temperature that is comfortable, 12 per cent of all households at baseline (intervention 13 per cent and comparison 10 per cent) reported that they could not afford to do this. At follow-up the level of fuel poverty, using this indicator, fell to 2 per cent overall or to 1 per cent among intervention households and 2 per cent among control households.

Similarly, using the indicator of not occupying rooms in households because they are not heated or too cold, found that at baseline 9 per cent of all households reported this problem – 15 per cent of intervention households compared with 4 per cent of comparison households ($p<=0.001$). At follow-up, however, just 3 per cent of all households reported this problem, with a significant fall reported by intervention households (down from 15 per cent to 2 per cent, $p<=0.001$) and no change among comparison households (i.e. 4 per cent at baseline and follow-up).

Household Damp, Mould Growth and Condensation

Given the research evidence of a link between ill-health and damp, mould and condensation, a number of questions was included in the study to assess the levels of damp, mould growth and condensation within households.

Damp Table Salt

One indicator of household damp is whether or not table salt is ever damp. Among intervention households, 17 per cent at baseline reported having damp table salt compared with 7 per cent at follow-up ($p<=0.001$). Among comparison households the same pattern of response was reported, though it was less significant than among the intervention households (16 per cent compared with 10 per cent, $p<=0.05$).

Patches of Damp/Mould

Overall, 44 per cent of baseline intervention households reported having patches of damp or mould in their homes compared with 17 per cent at follow-up ($p<=0.001$). Although not as marked, there was also a reduction in the proportion of comparison households reporting patches of damp or mould at follow-up compared with baseline (down from 39 per cent to 23 per cent, $p<=0.001$).

With regard to intervention households, there were significant falls in the proportion of households reporting damp mould patches in their living rooms at follow-up compared with baseline (down from 10 per cent to 2 per cent, $p<=0.01$), with significant falls also reported for kitchens (down from 14 per cent to 4 per cent, $p<=0.01$), master bedrooms (down from 15 per cent to 4 per cent, $p<=0.001$), second bedrooms (down from 21 per cent to 9 per cent, $p<=0.001$) and for third bedrooms (down from 14 per cent to 7 per cent, $p<=0.05$).

In relation to comparison households between baseline and follow-up, there were falls in the level of damp/mould patches reported in living rooms (down from 11 per cent to 5 per cent, p<=0.05), master bedrooms (down from 17 per cent to 7 per cent, p<=0.001), second bedrooms (down from 16 per cent to 8 per cent, p<=0.05) and bathrooms (down from 7 per cent to 2 per cent, p<=0.05).

Table 1 Rooms With Damp / Mould Patches

	Intervention Baseline	Intervention Follow-up	Comparison Baseline	Comparison Follow-up
	%	%	%	%
Living Room	10	2*	11	5*
Dining Room / Study	2	1	4	1
Kitchen	14	4*	9	7
Master Bedroom	15	4*	17	7*
Bedroom 2	21	9*	16	8*
Bedroom 3	14	7*	11	9
Bedroom 4	3	1	3	1
Bathroom (s)	10	6	7	2*
* Statistically Significant: p<=0.05				

Condensation

At baseline, just over half (54 per cent) of intervention households reported experiencing condensation in their home, compared with 9 per cent at follow-up (p<=0.001). This pattern of response was found to be consistent among comparison households, with a decrease from 42 per cent experiencing condensation at baseline compared with 16 per cent at follow-up (p<=0.001).

Table 2 Experience Condensation

	Intervention Baseline	Intervention Follow-up	Comparison Baseline	Comparison Follow-up
	%	%	%	%
Living Room	18	7*	17	6*
Dining Room / Study	5	5	8	4*
Kitchen	45	8*	34	14*
Master Bedroom	28	7*	21	7*
Bedroom 2	26	8*	20	6*
Bedroom 3	19	7*	18	6*
Bedroom 4	9	1*	4	0*
Bathroom (s)	44	8*	37	13*
* Statistically Significant: p<=0.05				

Among the intervention group, the change between baseline and follow-up in the proportion of households reporting condensation in their living rooms fell significantly, from 18 per cent to 7 per cent (p<=0.001), with significant reductions also recorded for kitchens (down from 45 per cent to 8 per cent, p<=0.001), master bedrooms (down from 28 per cent to 7 per cent, p<=0.001), second bedrooms (down from 26 per cent to 8 per cent, p<=0.001), third bedrooms (down from 19 per cent to 7 per cent, p<=0.001), fourth bedrooms (down from 9 per cent to 1 per cent, p<=0.001) and bathrooms (down from 44 per cent to 8 per cent, p<=0.001).

Among the comparison group there was also a number of significant changes reported between baseline and follow-up (living rooms: from 17 per cent to 6 per cent, p<=0.001; dining rooms/study: from 8 per cent to 4 per cent, p<=0.05; kitchens: from 34 per cent to 14 per cent, p<=0.001; master bedroom: from 21 per cent to 7 per cent, p<=0.001; second bedrooms: from 20 per cent to 6 per cent, p<=0.001; third bedrooms: from 18 per cent to 6 per cent, p<=0.001; fourth bedrooms: from 4 per cent to 0 per cent, p<=0.001; and bathrooms: from 37 per cent to 13 per cent, p<=0.001).

Regression analysis was used to explain the change in condensation level (dependent variable) and to identify significant associations between the change in condensation and a range of explanatory factors (i.e. independent variables) including: whether the household is in the intervention group or comparison group; energy efficiency measures installed (e.g. lagging jacket, loft/attic insulation etc); year house was built etc. A full list of the independent variables is included in Table 3 (note that measures installed as part of the Warmer Homes Scheme are listed in bold and italics). Note that independent variables significantly associated with the dependent variable are highlighted with an asterisk. The model produced an r-squared figure of 0.15 which means that the model explained 15 per cent of the variation in the dependent variable (i.e. change in condensation). It should also be noted that it is likely that other factors may explain variation in condensation, including external temperature as well as the temperature of rooms other than the main living room. However, these data were not captured as part of the study.

The change in the amount of condensation was examined further in a logistic regression that also incorporated the effects of age of house, house type, whether the house had central heating at the time of the follow-up, the amount spent on fuel per room at the time of follow-up and the amount of fuel subsidy received at the time of follow-up. Those households in the intervention group and households that had had a water tank lagging jacket installed were more likely ($p < 0.05$) to report a favourable change in that they no longer had condensation problems. Households that had central heating or that had had a lagged water tank installed were less likely ($p < 0.05$) to report that they now had condensation problems. However, those that received a fuel subsidy were less likely ($p < 0.05$) to report that they no longer had condensation problems at the time of the follow-up survey. Neither the age of the house, the amount currently spent on fuel per room nor the installation of any of the other energy efficiency devices had significant effects on the change in condensation in the house.

Table 3: Logistic regression analysis of change in condensation by the time of the follow-up survey	
Variable	Wald coefficient
No longer any condensation in home at time of follow-up[a]	
Household in intervention group[1]	4.918*
Lagging jacket installed	***4.895****
Loft, attic or ceiling insulation installed	***3.039 ns***
Wall insulation installed	***0.186 ns***
Door draught-proofing installed	***0.037 ns***
Window draught-proofing installed	***0.028 ns***
Low energy light bulbs installed	***0.022 ns***
House has central heating	2.080 ns
Detached house[2]	0.385 ns
Fuel expenditure per room	0.036 ns
Amount of fuel subsidy	0.431 ns
Year house was built	1.365 ns
Floor insulation installed	0.260 ns
Double glazing installed	0.003 ns
Central heating controls or timer installed	0.025 ns
Index of no. of energy-saving devices	2.833 ns
House now has condensation at time of follow-up[b]	
Household in intervention group[1]	0.977 ns
House has central heating	3.809*
Lagging jacket installed	4.475*
Loft, attic or ceiling insulation installed	2.360 ns
Wall insulation installed	0.431 ns
Door draught-proofing installed	1.854 ns
Window draught-proofing installed	0.841 ns
Low energy light bulbs installed	3.494 ns
Detached house[2]	0.003 ns
Fuel expenditure per room	1.355 ns
Amount of fuel subsidy	4.168*
Year house was built	0.726 ns
Floor insulation installed	NA
Double glazing installed	0.072 ns
Central heating controls or timer installed	1.105 ns
Index of no. of energy-saving devices	0.196 ns
Items in bold and italic relate to measures installed as part of the Warmer Homes Scheme.	

ns = Not significant, * = $p < 0.05$, ** = $p < 0.01$

[a] House had condensation at the time of the baseline survey.

[b] House did not have condensation at the time of the baseline survey.

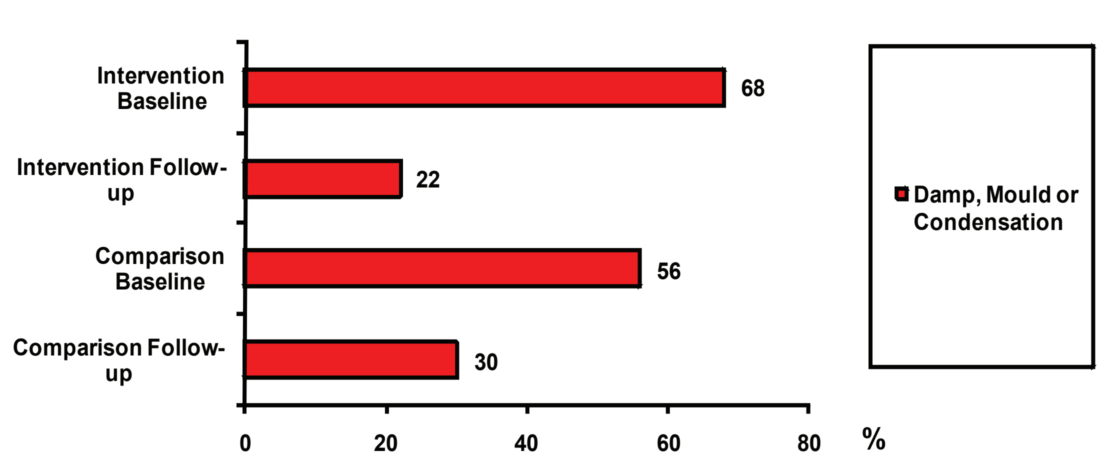
Overall comparator is that there has been no change in condensation between the baseline and follow-up surveys.

[1] Comparator is household is in the control group

[2] Comparator is terraced house.

Prevalence of Damp, Mould or Condensation

Fig 1: Prevalence of damp, mould or condensation?



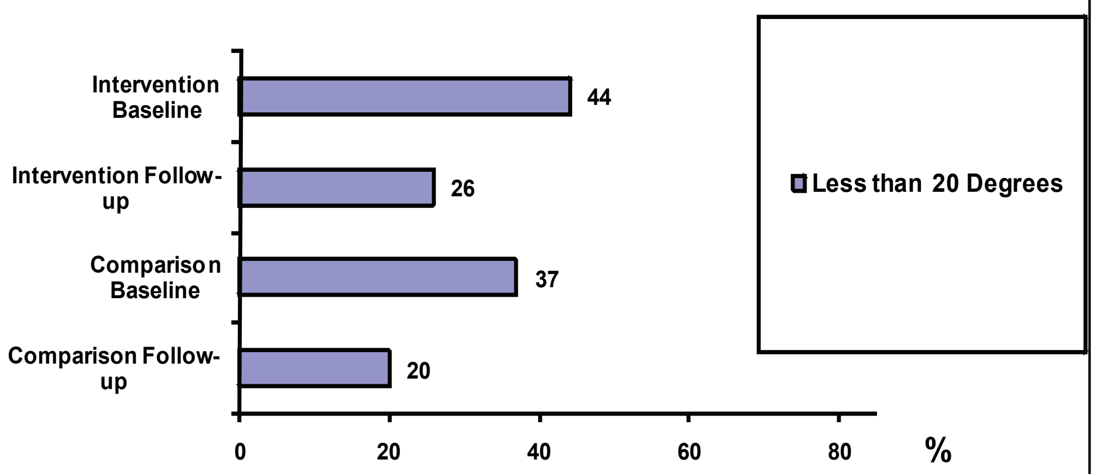
Overall, the proportion of intervention households reporting that they experienced damp, mould or condensation fell by 46 percentage points, from 68 per cent at baseline to 22 per cent at follow-up ($p<=0.001$), with the proportion of comparison households reporting these problems falling by 26 percentage points, from 56 per cent at baseline to 30 per cent at follow-up ($p<=0.001$).

Household Temperature

The link between indoor temperature and health risk is well documented in the literature, particularly the work of Raw (ibid). Before commencing with the interview, interviewers were instructed to place a temperature strip on a surface in the most commonly used room in the respondent's home. Using the temperature benchmark of 20°C for those aged 65+ set by the World Health Organisation, the target for household ambient temperature was set at 20°C.

Figure 1 shows that having controlled for time of year, among intervention households there was a significant fall in the proportion of households recording an ambient temperature of less than 20°C (down from 44 per cent at baseline to 26 per cent at follow-up: $p<=0.001$). However, the data also show a significant fall in the proportion of comparison households recording an ambient temperature of less than 20°C (down from 37 per cent at baseline to 20 per cent at follow-u,: $p<=0.001$).

Fig 2: Temperature of Households



Within the two localities, there were some differences. For example, in Donegal the majority (53 per cent) of intervention households at baseline recorded temperatures of less than 20°C compared with 9 per cent at follow-up ($p<=0.001$), whereas in Cork the reverse was true, with 26 per cent of intervention households recording ambient temperatures of less than 20°C compared with 61 per cent at follow-up ($p<=0.001$). In relation to the comparison group, there was no significant change among Cork households, with a fall from 55 per cent to 14 per cent ($p<=0.001$) recorded among the comparison households in Donegal.

Between baseline and follow-up, intervention households with children were significantly more likely ($p<=0.05$) to record a drop in the proportion of households with temperatures of less than 20°C (43 per cent down to 0 per cent) whereas the change was not significant among comparison households with children (down from 41 per cent to 13 per cent: $p<=0.07$).

The mean temperature difference between the baseline and follow-up surveys was just over one degree. While the intervention group recorded a slightly higher rise (+1.25 degree) compared to the control group (+0.92 degree), the difference between the groups was not significant.

Regression analysis was used to explain the change in recorded temperature (dependent variable) and to identify significant associations between the change in temperature and a range of explanatory factors (i.e. independent variables) including: whether the household is in the intervention group or comparison group; energy-efficiency measures installed (e.g. lagging jacket, loft/attic insulation etc); year house was built etc. A full list of the independent variables is included in Table 4 (note that measures installed as part of the Warmer Homes Scheme are listed in bold and italics). Note that independent variables significantly associated with the dependent variable are highlighted with an asterisk. The model produced an r-squared figure of 0.127 which means that the model explained 13 per cent of the variation in the dependent variable (i.e. change in temperature). It should also be noted that it is likely that a number of other factors may explain variation in temperature change, not least external temperature which was not recorded as part of the study.

The mean temperature difference between the baseline and follow-up surveys was just over one degree. While the intervention group recorded a slightly higher rise (+1.25 degree) compared to the control group (+0.92 degree), the difference between the groups was not significant. When the effects of house type (detached or not), the change in amount spent on heating between baseline and follow-up, age of house – plus an index of the number of fuel-efficiency devices installed between the two survey dates, along with the varieties of fuel efficiency devices: hot water tank lagging; loft, attic or ceiling insulation; floor insulation; wall insulation; double glazing; door draught-proofing; window draught-proofing; central heating timer or controls; low-energy light bulbs – are incorporated along with study group into a multivariate regression analysis, some of the energy efficiency devices are found to have an effect, with a significantly higher raised temperature difference in comparison to the intervention group. These are door draught-proofing (highly significant ($p < 0.001$) and double-glazing and central heating controls (both weakly significant ($p < 0.05$). In addition, the index of the overall number of energy-saving devices also has a weak, though statistically-significant effect on raised temperature. However, two of these interventions, door draught-proofing and double glazing, appear to be associated with colder temperatures recorded at the follow-up phase.[3]

Findings

3 The other variables – whether or not the houseful is in the intervention group, house type, change in fuel cost per room and age of house, and the other types of energy efficiency devices – are not significant.

Table 4: Regression analysis of change in recorded temperature by the time of the follow-up survey	
Variable	Standardised regression coefficient
Household in intervention group[1]	0.038 ns
Double glazing installed	-0.130*
Door draught-proofing installed	***-0.250*****
Central heating controls or timer installed	0.125*
Index of no. of energy-saving devices	0.376*
Lagging jacket installed	***-0.090 ns***
Loft, attic or ceiling insulation installed	***-0.012 ns***
Wall insulation installed	***0.115 ns***
Window draught-proofing installed	***0.083 ns***
Low energy light bulbs installed	***-0.073 ns***
Detached house[2]	0.044ns
Increase in fuel expenditure by time of follow-up[3]	0.007 ns
Year house was built	-0.012 ns
Floor insulation installed	-0.007 ns
Items in bold and italic relate to measures installed as part of the Warmer Homes Scheme.	

n.s= Not significant, *= p < 0.05, ***= p < 0.001

[1] Comparator is household is in the comparison group

[2] Comparator is terraced house.

[3] Controlling for number of rooms in the house.

Level of Comfort in Terms of Temperature in Winter

Respondents were asked to rate their level of comfort in terms of temperature in each of the rooms in their household. The level of comfort was scored on a 7 point scale from hot (+3) to cold (-3). Between baseline and follow-up, the level of comfort in the intervention households improved in respondents' kitchens (a reduction in the mean comfort score from -0.27 to +0.07, p<=0.001) and in respondents' master bedrooms (down from -0.31 to -0.16, p<=0.05). However, the level of comfort was found to have declined in second (-0.54 at baseline to -1.00 at follow-up, p<=0.001) and third bedrooms (-0.63 at baseline to -1.14, p<=0.001).

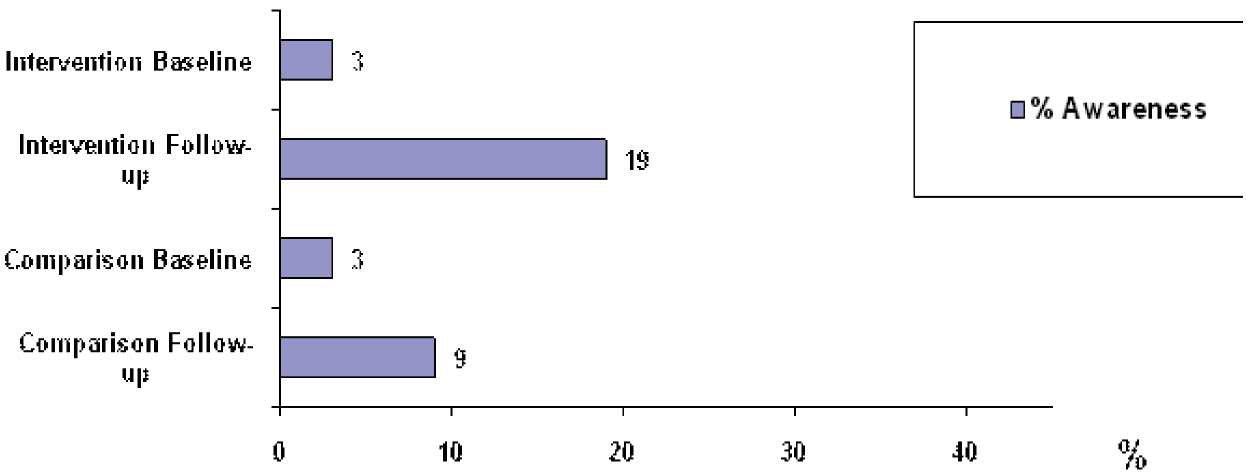
In relation to the comparison sample, Table 5 shows that the level of comfort was also found to have improved in kitchens, master bedrooms and bathrooms (p<=0.001).

Table 5 Respondent Rating of the Temperature of the Rooms in their Household				
	Intervention Baseline Mean	**Intervention Follow-Up Mean**	**Comparison Baseline Mean**	**Comparison Follow-Up Mean**
Living Room	**-.15**	**-.30**	**-.14**	**-.11**
Dining room/Study	**-.52**	**-.57**	**-.22**	**-.22**
Kitchen	**-.27**	**.07*****	**-.17**	**.02*****
Master bedroom	**-.31**	**-.16***	**-.29**	**-.12*****
Bedroom 2	**-.54**	**-1.00*****	**-.51**	**-.47**
Bedroom 3	**-.63**	**-1.14*****	**-.63**	**-.53**
Bathroom(s)	**-.46**	**-.34**	**-.54**	**-.26*****
Statistically Significant: * p<=0.05; ** p<=0.01; *** p<=0.001				

Knowledge of Temperature in Most Commonly Used Room

Respondents were asked if they knew what temperature the room they normally spend most time is kept at, with intervention households at follow-up (19 per cent) significantly ($p<=0.001$) more likely to be aware that the correct temperature is 20°C compared with other groups (baseline intervention, 3 per cent; baseline comparison, 3 per cent; and follow-up

Fig 3: Awareness of what temperature room spend most time in should be heated to?



comparison, 9 per cent).

The improvement in awareness levels between baseline and follow-up was statistically significant for both intervention ($p<=0.001$) and comparison households ($p<=0.01$), although it should be noted that the difference recorded by the intervention households achieved a higher level of statistical significance. Note also that the increase in awareness among intervention households was found to be statistically significant in Donegal (up from 3 per cent to 26 per cent: $p<=0.001$), but not statistically significant in Cork (no change at 3 per cent).

In intervention households with children, awareness of what the correct room temperature should be also improved, with none of these households at baseline being aware that 20°C is the optimum temperature compared with the majority (57 per cent) at follow-up. This compares with none of the comparison households being aware of the optimum temperature at baseline compared with 6 per cent at follow-up.

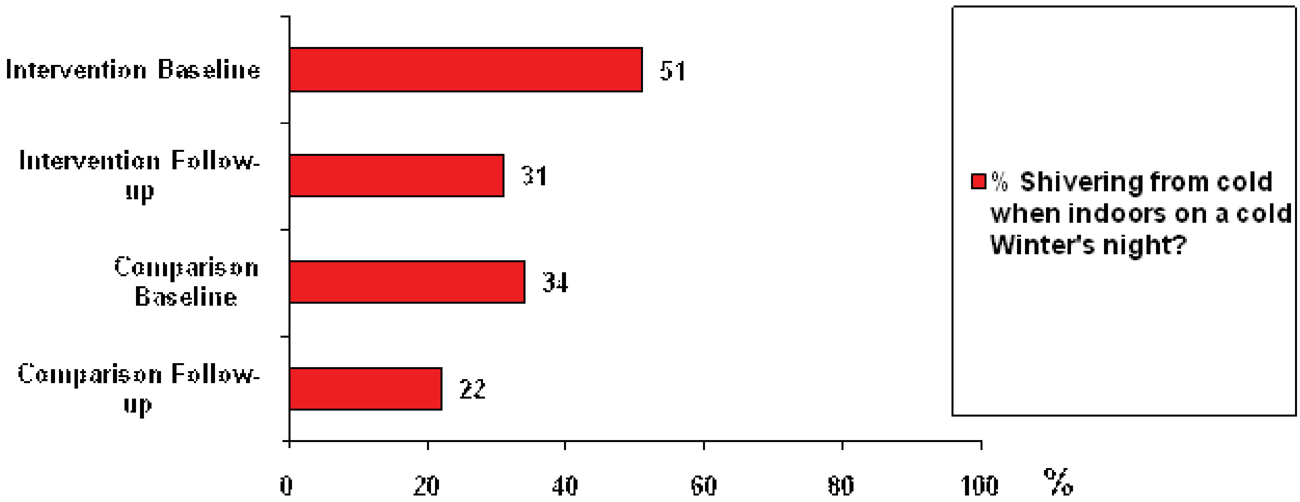
Temperature of Home in Winter

Respondents were asked if during winter, or more generally when it is cold outside, they heat their home to a temperature that is comfortable. There was no statistically significant variation in response to this question by study group, with almost all households reporting that they heat their home to a temperature that is comfortable in winter (intervention baseline, 97 per cent; intervention follow-up, 96 per cent; comparison baseline, 95 per cent; comparison follow-up, 94 per cent).

Indoor Cold Strain

Between baseline and follow-up there was a fall in the proportion of respondents living in intervention households who said they would shiver from the cold for at least a few minutes when indoors on a cold winter's night (down from 51 per cent to 31 per cent, p<=0.001), with a less significant fall recorded among comparison households (down from 34 per cent

Fig 4: Shivering from cold when indoors on a cold Winter's night



to 22 per cent, p<=0.05).

Among baseline intervention households with children, 50 per cent reported that they would shiver from the cold for at least a few minutes when indoors on a cold winter's night compared with 14 per cent at follow-up. The comparative figures for comparison households with children was an increase from 41 per cent to 56 per cent.

In terms of property age, intervention households living in properties dated post-1960 were more likely to record a fall in the proportion of respondents who indicated that they would shiver from the cold for at least a few minutes when indoors on a cold winter's night (down from 55 per cent to 33 per cent, p<=0.001), whereas the reduction was less significant in properties built pre-1960 (down from 47 per cent to 38 per cent).

In relation to property type, the greatest reduction in the proportion of respondents in intervention households reporting that they would shiver when coming in from the cold on a winter's night was recorded by those living in terraced properties (down from 53 per cent to 17 per cent compared with other types of intervention property (detached: down from 51 per cent to 40 per cent: semi-detached, down from 52 per cent to 27 per cent).

Cold Stress

At baseline, just 3 per cent of all respondents (4 per cent intervention and 2 per cent comparison) said that they 'feel cold and often shiver' ('cold stress') when they go out into the open air in winter. This fell to 1 per cent at follow-up (intervention and comparison respondents both 1 per cent). The majority of respondents in intervention households (67 per cent) said that they shivered from the cold when outdoors on a cold winter's day, compared with a minority (40 per cent) at follow-up (p<=0.001). By comparison, the difference between respondents in the comparison households was not significant (baseline, 69 per cent; follow-up, 59 per cent).

Note that there were no significant differences in the wearing of items of clothing on a cold day between intervention households at baseline and follow-up, or between comparison households at baseline or follow-up. Note also that there was no significant difference between baseline and follow-up in the proportions of intervention respondents who said they needed to go outside their home to get fuel, feed pets or shop on a daily basis (72 per cent vs. 80 per cent). The same pattern of response existed for respondents in comparison households (58 per cent vs. 59 per cent).

Installation of Energy Efficiency Measures

Households accepted onto the Warmer Homes Scheme have a range of energy saving measures installed (listed in Tables 3 and 4 with the exceptions of double glazing and timer/central-heating controls). Among intervention households, and with the exception of floor insulation, there were significant increases (p<=0.001) in the proportions of households reporting that they had various energy efficiency measures installed (e.g. hot water cylinder lagging jackets: up from 51 per cent at baseline to 81 per cent at follow-up[1]).

Among comparison households, and with the exceptions of draught proofing on doors and timer/central heating controls, there were significant increases in the proportion of households reporting that they had a range of energy-efficiency measures (e.g. hot water cylinder lagging jackets: up from 58 per cent at baseline to 82 per cent at follow-up).

Table 6 Energy Efficiency Measures Installed[1]

	Intervention Baseline		Intervention Follow-Up		Comparison Baseline		Comparison Follow-Up	
	%	n	%	n	%	n	%	N
Hot-water cylinder lagging jacket	51	91	81	146	58	149	82	209
Roof /attic/loft insulation	45	80	83	150	51	126	79	200
Wall insulation	22	38	66	119	15	35	45	96
Double-glazing	77	138	90	162	77	196	88	226
Draught-proofing on doors	37	66	94	169	39	98	79	168
Draught-proofing on windows	56	101	69	124	72	182	65	167
Low energy light-bulbs	34	61	93	167	40	102	81	206
Timer/central-heating controls	76	136	87	156	88	225	94	240

So, while intervention households had significantly increased the proportion of energy saving devices, the comparison households had done so as well. The crucial question is whether the intervention group had installed significantly more energy efficiency devices.

Findings

1 Note that is normal policy that every household within the Warmer Homes Scheme is fitted with a lagging jacket, with respondents asked to comment on whether or not a lagging jacket had been installed. Interviewers were not instructed to physical ly check for the presence of installation measures.

Table 7 Percentages of households installing energy efficiency devices between baseline and follow-up surveys		
	Intervention (%)	Comparison (%)
Hot-water cylinder lagging jacket*	35.0	25.4
Floor insulations ns	0.6	1.2
Roof /attic/loft insulation***	43.3	28.5
Wall insulation***	45.0	23.8
Double-glazing ns	16.1	15.6
Draught-proofing on doors***	57.2	30.9
Draught-proofing on windows***	28.9	13.7
Low energy light-bulbs***	60.6	43.4
Timer/central-heating controls**	16.7	7.4
ns = Not significant; * = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$		

As Table 7 shows, in most instances except for floor insulation and double-glazing the intervention group installed significantly more energy efficiency devices. Usually the difference was highly significant ($p < 0.001$), with the intervention group being approximately twice as likely to have installed a given device. The intervention households on average had installed one more device than the comparison households (2.6 compared to 1.6 devices) and this difference was highly significant ($p < 0.001$).

Smoke Alarms

The proportion of intervention households having a smoke alarm increased from 92 per cent at baseline to 97 per cent at follow-up, with a similar pattern of response reported by households in the comparison sample (up from 88 per cent to 93 per cent). This suggests a slight improvement in fire safety in both the intervention and comparison households.

Outdoor Activity/ Getting About

During the winter, when going about on daily business during the week (e.g. travelling to work, going shopping, visiting friends) the most common mode of transport for all study groups was to drive, which increased from 42 per cent to 54 per cent among the intervention group and from 45 per cent to 57 per cent in the comparison group. The only other notable difference between baseline and follow-up was the decrease in the proportion of comparison households saying that they normally walk (down from 20 per cent to 13 per cent: $p<=0.05$).

Table 8 During the winter when you go about your daily business during the week e.g. travelling to work, going shopping, visiting friends, do you normally:				
%	Intervention Baseline	Intervention Follow-up	Comparison Baseline	Comparison Follow-up
	%	%	%	
Drive	**42**	**54**	**45**	**57**
Get a Lift	**22**	**26**	**13**	**18**
Walk	**16**	**14**	**20**	**13**
Get a Bus	**12**	**1**	**15**	**7**
Take a Taxi-Cab	**4**	**2**	**3**	**2**
Take a Community Bus Service	**1**	**1**	**1**	**-**
Cycle	**-**	**-**	**-**	**-**
Get a Train	**-**	**1**	**0**	**0**
Other	**2**	**1**	**4**	**1**

Spending Time in the 'Open Air'

At baseline, 66 per cent of respondents in intervention households said that in a typical day in winter they would spend more than an hour in the open air, compared with 41 per cent at follow-up p<=0.001). Among comparison households there was no significant change, with 62 per cent at baseline saying that they spend more than one hour in the open air on a typical day compared with 6 per cent at follow-up.

For both intervention and comparison groups there was no significant difference between baseline and follow-up in the proportions of respondents who said that when going out in winter they feel cold and often shiver (baseline intervention: 2 per cent; follow-up intervention, 2 per cent; baseline comparison, 1 per cent; follow-up comparison, 2 per cent).

Conclusions

On one of the key indicators of fuel poverty (i.e. thermal comfort), the research evidence shows a significant decline in the number of intervention households reporting difficulty in being able to afford to heat their homes in winter to a temperature that is comfortable and a decline in the proportion of intervention household not using rooms in their home because they are not heated or too cold.

Although similar shifts have been recorded by intervention households, these shifts were found to be less significant. Indeed a common theme to emerge from the study is that many of the outcomes documented by intervention households have also been reported by comparison households. On this point, the research has found that both intervention and comparison households had an average of 4 energy efficiency measures installed at baseline. However, at follow-up the average number of energy efficiency measures increased significantly not only for the intervention households (an average of 7 energy efficiency measures) via the Warmer Homes Scheme, but also for comparison households (an average of 7 energy efficiency measures installed).

Given the strong research evidence of a link between household damp and ill-health, it is reassuring to find that the proportion of intervention households reporting the prevalence of damp, mould growth or condensation had fallen, from 68 per cent to 22 per cent. Indeed when a range of factors was controlled for, intervention households were also more likely to report a fall in condensation level. The health impacts of a fall in household humidity are well documented in the literature (i.e. viruses giving rise to infections, nausea, respiratory symptoms, backache, fainting etc) and the evidence from this study suggests that the significant number of intervention households reporting an improvement in the level of damp, mould and condensation are now living in homes that are more conducive to good health.

Based on the use of temperature thermometers, and after controlling for a number of other factors, the evidence from this study shows a significant rise in the indoor temperature of intervention households. This is also supported by the finding that household temperature increases significantly as the number of energy efficiency measures increases. Specifically, the installation of draught-proofing measures appears to be associated with raised temperature. Also the evidence points to a positive correlation between number of energy efficiency measures installed and increased temperature, which underscores the importance of the Warmer Homes Scheme in improving the thermal comfort of households benefiting from the initiative. This is particularly the case with low-income households who, through lack of resources, would struggle to improve the physical fabric of their homes in the absence of a capital improvement programme such as the Warmer Homes Scheme. The benefits of the scheme are also highlighted by the finding that at follow-up there was a significant fall in the proportion of intervention households falling below the World Health Organisation's (ibid) benchmark of heating the most commonly lived in room to 20°C.

In addition to providing households with a range of energy efficiency measures, the Warmer Homes Scheme is also tasked with promoting awareness of energy efficiency including appropriate household temperature. The evidence from this research suggests that the programme has had a significant impact on household awareness of the WHO benchmark temperature (20°C), with intervention households showing a more marked increase in awareness relative to comparison households.

There is also evidence that intervention households are finding it easier to heat their homes to a temperature that is comfortable, although this was also found to be the case among comparison households. There is a number of possible explanations for this including the positive impacts of the energy efficiency measures in households as well as a better awareness of energy efficiency issues. However, the survey did find that there was a significant increase in the proportion of all households availing of fuel subsidies at follow-up (up from 69 per cent to 85 per cent among intervention households and up from 66 per cent to 83 per cent of comparison households). It is likely that this may have contributed to increased affordability.

The research also found a fall in the proportion of intervention households reporting indoor cold strain, with this trend also reported by comparison households albeit at a less significant level. This suggests that these households are at reduced risk of adverse health effects such as cardiovascular strain and potentially more serious conditions such as hypothermia and pneumonia. Similarly, in relation to 'cold stress', the research has found a fall (down from 4 per cent to 1 per cent) in the proportion of intervention respondents reporting this problem.

References

Acheson, D. (1998), *Health inequalities*, DOH
Alderson, M.R. (1985), 'Season and mortality', *Health trends*, 17, 87-96
Boardman,B. (1991), *Fuel poverty: from cold homes to affordable warmth*, London: Belhaven Press
Byrne, D. and Keithley, J. (1993), 'Housing and the health of the community', in Burridge, R. and Ormandy, D. (eds), *Unhealthy housing*, E&FN Spon
Carswell, F. and Thompson, S.J. (1987), 'Percutaneous sensitisation to house dust mite may occur naturally in eczema', *Int. Arch. Allergy Appl. Immunology*, 82, 453-455
Centre for Sustainable Energy, http://www.cse.org.uk/pdf/fphealth-review.pdf
Collins, K.J., Easton, J.C., Belfield-Smith, H., Exton Smith, A.N. and Pluck, R.A. (1985), 'Effects of age on body temperature and blood pressure in cold environments', *Clinical Science*, 69, 465-470
Curwen, M. (1991), 'Temperature and cardiovascular mortality', *The Lancet*, 345, 337-338, Feb 11
Department of the Environment Food and Rural Affairs (*1999)*
Energy Action Scotland (1998), *The impact of fuel poverty and housing conditions on Scotland's health*, Energy Action Scotland
Energy Research Group & Environmental Institute (1999), *Homes for the 21st Century – The Costs and Benefits of Comfortable Housing for Ireland*. Dublin: Energy Action, UCD
ESRI (2009), Scott, S., Lyons, S., Keane, C., McCarthy, D. and Tol. R.S.J. 'Fuel poverty in Ireland: Extent, Affected Groups and Policy Issues', *Working Paper No. 262*, November 2008.
Eurowinter Group (1997), 'Cold exposure and winter mortality from ischaemic heart disease, cerebrovascular disease, respiratory disease, and all causes in warm and cold regions of Europe', *The Lancet*, 349, 1341-1346
Goodwin, J. (2000), 'Cold stress, circulatory illness and the elderly', in Rudge, J. and Nicol, F. (eds), *Cutting the cost of the cold*, E&FN Spon
Hatch, M.T., Holmes, M.J., and Deig, E.F. (1976), 'Stability of airborne Rhinovirus'
Healy, J. (2004), *Fuel Poverty and Health: A Pan European Analysis*, Ashgate Publishing Ltd
Henwood, M. (1997), *Fuel poverty, energy efficiency and health*, Eaga Charitable Trust

Howarth, P.H., Lunn, A. and Tomkins, S. (1992), 'A couble-blind, placebo controlled trial of intervent bedding system in perennial allergic rhinitis', *Journal of Allergy Clinical Immunology*, 89, 305

Howieson, S.G., McSharry, C., Morris, G., McKenzie, E., and Young, D. (2001), Energy efficiency, indoor air quality and asthma (unpublished)

Hunt, S. (1993), 'Damp and mouldy housing: a holistic approach' in Burridge, *op cit*

Institute of Public Health in Ireland, Press Release (NI): IPH welcomes reduction in winter deaths but concerned by rising fuel poverty – 15 Dec 2008

Keatinge, W.R. (1986), 'Seasonal mortality among elderly people with unrestricted home heating', *British Medical Journal*, 293, 732-733

Khamano Study (quoted by Centre for Sustainable Energy), http://www.cse.org.uk/pdf/fphealth-review.pdf

NEA, http://www.nea.org.uk/fuel-poverty-and-energy-efficiency

Platt, S.D., Martin, C.H., Hunt, S.M., and Lewis, C.W. (1993), 'Damp housing, mould growth, and symptomatic health state', *British Medical Journal*, 298, 1673-1678, 24 June

Raw, G.J. and Hamilton, R.M. (eds) (1995), *Building regulation and health*, Building Research Establishment

Raw, G.J., Aizlewood, C.E. and Hamilton, R. (2001), *Building regulation, health and safety*, Building Research Establishment

Review of Fuel Poverty in Scotland. Scottish Government 2008

Somerville, M., Mackenszie, I., Owen, P. and Miles, D., 'Housing and health: does installing heating in their homes improve the health of children with asthma?', *Public Health*, 114, 434-439

Sustainable Energy Ireland (2009), *Low Income Housing Programme*

WHO (1987), *Health Impact of Low Indoor Temperature*, Copenhagen, WHO Regional Office for Europe

Wilkinson, P., Landon, M., Armstrong, B., Stevenson, S., Pattenden, S., Fletcher, T. and McKee, M. (2001), *Cold comfort: The social and environmental determinants of excess winter death in England, 1986-96*, Bristol: Policy Press

(Footnotes)

1 Note that these figures relate to those who answered 'yes' with the remaining respondents recording 'no' or 'don't know'.

Appendix (Output from Multivariate Analysis)

Model 1

Regression analysis was conducted with temperature difference between baseline and follow-up used as the dependent variable. The independent variables used in the regression were:

Intervention group (dummy)
Detached house dummy
Fuel cost change taking account of the number of rooms in house
Year house built
Lagging jacket installed
Floor insulation installed
Roof loft insulation installed
Wall insulation installed
Double glazing installed
Door draft-proofing installed
Window draft-proofing installed
Low energy bulbs installed
Central heating controls installed
Number of energy efficiency measures installed between baseline and follow-up

Appendix

This model produced an adjusted R Square of 0.127 which means that the model explained 12.7% of the variation in temperature between baseline and follow-up.

Model		B	Std. Error	Beta	t
1	(Constant)	.731	.511		1.430
	Intervention group (dummy)	.214	.315	.038	.681
	Detached house dummy	.538	.621	.044	.868
	Fuel cost change taking # rooms into account	.000	.002	.007	.130
	Year house built	-.013	.061	-.012	-.220
	Lagging jacket installed	-.556	.429	-.090	-1.296
	Floor insulation installed	-.181	1.340	-.007	-.135
	Roof loft insulation installed	-.073	.423	-.012	-.172
	Wall insulation installed	.685	.409	.115	1.673
	Double glazing installed	-1.043	.528	-.130	-1.977
	Door draft-proofing installed	-1.448	.386	-.250	-3.755
	Window draft-proofing installed	.551	.461	.083	1.195
	Low energy bulbs installed	-.410	.397	-.073	-1.032
	Central heating controls installed	1.116	.522	.125	2.137
	Number of energy efficiency measures installed between baseline and follow-up	.541	.240	.376	2.261

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.402a	.161	.127	2.61284

ANOVAb

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	448.201	14	32.014	4.689	.000a
	Residual	2327.979	341	6.827		
	Total	2776.180	355			

Appendix

Model 2

Regression analysis was conducted with change in condensation between baseline and follow-up used as the dependent variable. The independent variables used in the regression were:

Number of energy efficiency devices installed
Fuel expenditure by room
Central heating controls or timer installed
Window draught proofing installed
Double glazing installed
Loft insulation installed
Lagging jacket installed
Intervention group (dummy)
Detached house (dummy)
Central heating installed
Floor insulation installed
Wall insulation installed
Door draught proofing installed
Low energy light bulbs installed
Year house was built
Fuel subsidy

Appendix

This model produced an adjusted R Square of 0.153 which means that the model explained 15.3% of the variation in condensation between baseline and follow-up.

Model		B	Std. Error	Wald	df	Sig.	Exp(B)
-1	Intercept (No longer condensation)	-1.983	2.091	.900	1	.343	
	Number of energy efficiency devices installed	.301	.179	2.833	1	.092	1.351
	Fuel expenditure by room	.000	.001	.036	1	.849	1.000
	Central heating controls or timer installed (=0)	-.064	.399	.025	1	.873	.938
	Central heating controls or timer installed (=1)	0b	.	.	0	.	.
	Window draught proofing installed (=0)	.058	.348	.028	1	.867	1.060
	Window draught proofing installed (=1)	0b	.	.	0	.	.
	Double glazing installed (=0)	.022	.382	.003	1	.955	1.022
	Double glazing installed (=1)	0b	.	.	0	.	.
	Loft insulation installed (=0)	.558	.320	3.039	1	.081	1.747
	Loft insulation installed (=1)	0b	.	.	0	.	.
	Lagging jacket installed (=0)	.723	.327	4.895	1	.027	2.060
	Lagging jacket installed (=1)	0b	.	.	0	.	.
	Intervention group (dummy) (=0)	-.534	.241	4.918	1	.027	.586
	Intervention group (dummy) (=1)	0b	.	.	0	.	.
	Detached house (dummy) (=0)	.311	.501	.385	1	.535	1.364
	Detached house (dummy) (=1)	0b	.	.	0	.	.
	Central heating installed (=0)	.738	.512	2.080	1	.149	2.091
	Central heating installed (=1)	0b	.	.	0	.	.
	Floor insulation installed (=0)	.605	1.187	.260	1	.610	1.831
	Floor insulation installed (=1)	0b	.	.	0	.	.
	Wall insulation installed (=0)	-.131	.303	.186	1	.666	.877
	Wall insulation installed (=1)	0b	.	.	0	.	.
	Door draught proofing installed (=0)	.058	.304	.037	1	.848	1.060
	Door draught proofing installed (=1)	0b	.	.	0	.	.
	Low energy light bulbs installed (=0)	.044	.300	.022	1	.883	1.045
	Low energy light bulbs installed (=1)	0b	.	.	0	.	.
	Year house was built	-.056	.048	1.365	1	.243	.945
	Fuel subsidy	.000	.001	.431	1	.512	1.000

Appendix

Model		B	Std. Error	Wald	df	Sig.	Exp(B)
0	Intercept (Now condensation)	-15.194	3.373	20.293	1	.000	
	Number of energy efficiency devices installed	-.150	.340	.196	1	.658	.860
	Fuel expenditure by room	-.005	.004	1.355	1	.244	.995
	Central heating controls or timer installed (=0)	-.997	.949	1.105	1	.293	.369
	Central heating controls or timer installed (=1)	0b	.	.	0	.	.
	Window draught proofing installed (=0)	1.061	1.158	.841	1	.359	2.891
	Window draught proofing installed (=1)	0b	.	.	0	.	.
	Double glazing installed (=0)	.244	.913	.072	1	.789	1.277
	Double glazing installed (=1)	0b	.	.	0	.	.
	Loft insulation installed (=0)	-.921	.600	2.360	1	.124	.398
	Loft insulation installed (=1)	0b	.	.	0	.	.
	Lagging jacket installed (=0)	1.914	.905	4.475	1	.034	6.782
	Lagging jacket installed (=1)	0b	.	.	0	.	.
	Intervention group (dummy) (=0)	.577	.583	.977	1	.323	1.780
	Intervention group (dummy) (=1)	0b	.	.	0	.	.
	Detached house (dummy) (=0)	.062	1.130	.003	1	.956	1.064
	Detached house (dummy) (=1)	0b	.	.	0	.	.
	Central heating installed (=0)	1.687	.864	3.809	1	.051	5.401
	Central heating installed (=1)	0b	.	.	0	.	.
	Floor insulation installed (=0)	13.815	.000	.	1	.	999150.269
	Floor insulation installed (=1)	0b	.	.	0	.	.
	Wall insulation installed (=0)	.505	.769	.431	1	.512	1.657
	Wall insulation installed (=1)	0b	.	.	0	.	.
	Door draught proofing installed (=0)	-.916	.673	1.854	1	.173	.400
	Door draught proofing installed (=1)	0b	.	.	0	.	.
	Low energy light bulbs installed (=0)	-1.150	.615	3.494	1	.062	.316
	Low energy light bulbs installed (=1)	0b	.	.	0	.	.
	Year house was built	-.086	.101	.726	1	.394	.917
	Fuel subsidy	-.003	.001	4.168	1	.041	.997

The reference category is 1 (no change)

Model Fitting Information

Model	Model Fitting Criteria	Likelihood Ratio Tests		
	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	703.148			
Final	634.428	68.720	32	.000

Pseudo R-Square

Cox and Snell	.153
Nagelkerke	.187
McFadden	.097