seai 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 3: Health Impacts

social market research SMR

Published by:

Social Inclusion Division
Department of Social and Family Affairs

ISBN: 978 0 9563903 5 6

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
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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 health benefits of 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

A key aspect of the study was to examine the impact of installing a range of energy efficiency measures on the health status of households.

Given the resources 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. 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 (2008) 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, reflected in a number of key policy documents including the National Action Plan for Social Inclusion (2007-2016), the Government White Paper Delivering a 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. comfort, health status, quality of life etc), and a disproportionate impact on low-income households, Sustainable Energy Ireland (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 required 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 include: 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 given the close association between the organisations and the local community (i.e. established credibility, local contacts, mitigating problems associated with accessibility etc).

Literature Review

Link between Ill-Health and Poor Housing

The link between 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 and 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.

Within health research, Byrne and Keithley (ibid) refer to two broad approaches:

- The medical approach of associating single causes with individual effects
- The public health approach of investigating causal systems, rather than single causal factors.

This current study is consistent with the public health approach which examines 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 review of the literature on fuel poverty suggests that there are three main factors which influence the level of fuel poverty, namely: fuel prices, household income, and energy efficiency of the housing stock. In acknowledging that fuel poverty significantly impacts on the lives of people affected, it is the interrelationships between low household income, poor energy efficiency and poor household comfort which produces adverse health impacts that have a disproportionate affect on low-income households. Thus, addressing fuel poverty through energy efficiency interventions not only improves the physical fabric of homes but also stimulates health gain by helping to reduce the incidence of those factors associated with causing ill-health, i.e. condensation, damp and mould etc.

The Centre for Sustainable Energy (CSE) (2009) in the UK states that the medical and public health approaches outlined previously require 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.

Although there are problems with applying the medical model to the links between health and housing (e.g. variation in diagnosis among doctors, the requirement of the patient to seek the services of a doctor which can lead to underestimating the extent of ill health in a community and medically diagnosed health being seen as a more reliable indicator compared with self-defined health), equally there are limitations with the public health approach. The Centre for Sustainable Energy states that:

> *… while the public health model provides a more holistic approach to combating ill health, it is difficult to disentangle the relative importance of the mix of measures the approach entails. For example, a before and after study of the health impact of a major regeneration programme may find that the community's overall health improves significantly. However, the study will not be able to determine with any degree of precision whether the improvement is due to improved housing, employment growth, income measures or improved social provision. Further, the health improvements may have arisen because of contemporary national policy initiatives, such as improved welfare benefits.*

The challenges documented by the CSE can sometimes be overcome by using what it terms 'control areas with similar characteristics to the area under investigation'. However, CSE also acknowledges the difficulty in identifying 'control areas with similar characteristics to the study area and to control for all possible causal factors'.

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

Specifically in relation to the impact of fuel poverty and health, Cheshire (2002) has put together a comprehensive review of the literature, with many studies focusing on either the effect of low indoor temperature (cold homes) on health or the effect of condensation, damp and mould (CDM) on health. In relation to cold homes, for example, the literature provides evidence of an increased risk of respiratory illness, increased blood pressure and risk of stroke, worsening arthritis, more frequent accidents in the home, social isolation, impaired mental health and adverse effects on children's education and nutrition (UK National Heart Forum, 2003). Allied to the problems associated with cold homes, damp is one of the most common problems associated with poor housing and is largely the result of poor insulation and inadequately heated homes. International Energy Action (1991) suggested a causal link between dampness and mould growth in dwellings and ill-health among household occupants. Indeed the house dust mite thrives in damp conditions and is considered a causal agent for asthma and other allergic diseases (ibid). Dampness has also been associated with vomiting, headaches, anxiety and depression (Revie, 1998) and in Northern Ireland Blackman et al (1989) found that damp homes increased levels of ill-health amongst householders. A number of studies has found a significant association between damp in households and increased levels of childhood asthma and other respiratory conditions (e.g. Williamson et al, 1997).

Seasonal variation in mortality is evident in most countries throughout Europe (Bøkenes et al, 2009), with a higher death rate in winter. A review of the impact of cold exposure on winter mortality found that mortality increased to a greater extent with a fall in temperature in regions with warmer winters, in populations with cooler homes, and among people who wore fewer clothes and who were less active outdoors (Euro Winter Study, 1997). Similar findings were recorded in a comparative study between Ireland and Norway (Eng et al, 1998) which found seasonal cardiovascular mortality to be higher in Ireland. Eng et al (ibid) suggest that this difference reflects, among other things, poorer housing standards and different thermoregulatory behavioural patterns in the elderly in Ireland compared with Norway. Bøkenes (ibid) investigated this and suggests that 'the generally poorly insulated and/or heated homes in the elderly ... living in Ireland may pose a hidden health risk, especially in the winter months'. This study further suggests that elderly people living in poorly insulated and/or poorly

heated homes may not be aware of the health risks associated with low air temperatures in their homes, even though they feel that their households are of sufficient temperature.

Data Collected

To evaluate the impact of the various programme interventions on the health status of households, a range of data was collected at the individual level including data on self-perceived health status, health risk behaviours (e.g. smoking, physical activity, diet etc), health conditions and use of health services.

Findings

Health Status

To evaluate the impact of the various programme interventions on the health status of households, the SF-36 (Ware, 1992) questionnaire was used in both the baseline and follow-up surveys. 'SF' stands for 'short form', and '36' refers to the 36 questionnaire items that measure different aspects of physical and mental health. The questionnaire was originally developed in the USA, where a much longer questionnaire was tested by the federal health authorities. This was subsequently reduced to 36 questions (SF-36) and was still found to give reliable results. This has since become known as the 'short' form.

SF-36 is the best-known questionnaire amongst experts in measuring health status and has proved to be valid and reliable. Health researchers have found it invaluable in measuring the sometimes subtle changes in health that follow medical and other interventions. The SF-36 has been used in over 2,000 published research studies, and is based on one multi-item scale that assesses eight health dimensions:

- limitations in physical activities because of health problems
- limitations in social activities because of physical or emotional problems
- limitations in usual role activities because of physical health problems
- bodily pain
- general mental health (psychological distress and well-being)
- limitations in usual role activities because of emotional problems
- vitality (energy and fatigue)
- general health perceptions.

The SF-36 was constructed for self-administration by persons aged 14 years and older, and for administration by a trained interviewer in person or by telephone. In the context of this study the SF-36 was used to compare the health status of the pre- and post-intervention samples and in turn make comparisons between the intervention and comparison households.

Table 1 presents an analysis of mean differences for the two groups between baseline and follow-up. There were no significant differences between the intervention and comparison groups in changes in health status dimensions between baseline and follow-up for six out of eight dimensions. However, for two dimensions – 'vitality' and 'general health' – the intervention group showed significant improvement.

Table 1 Differences in scores between baseline and follow-up surveys, scales and summary measures of the SF-36

	Intervention	Comparison
Physical functioning [ns]	**3.94**	**0.37**
Role physical [ns]	**1.68**	**-8.03**
Bodily pain [ns]	**-6.06**	**-1.79**
Vitality**	**-5.43**	**0.55**
Social functioning [ns]	**-1.01**	**2.19**
Role emotional [ns]	**1.68**	**-2.19**
Emotional wellbeing [ns]	**2.06**	**-0.82**

General health**	**-4.44**	**2.75**
ns = Not significant; ** = p < 0.01 **N.B: A negative sign indicates an improvement**		

Multiple regression analyses were carried out of the effects of various 'life style' variables upon 'Vitality' and 'General health'. The 'life style' variables encompassed:

- Five measures of physical activity at the time of the follow-up survey: mild exercise, moderate exercise, light housework, heavy housework, respondent's self-assessment of his/her level of activity

- Does the respondent currently smoke?

- Four measures of alcohol consumption at the time of the follow-up survey: days per week the respondent drinks, number of drinks on an average day, units of beer/stout/cider on an average day (all combined into a single index of alcohol consumption), units of spirits on an average day

- Five measures of food consumption. At the time of the follow-up survey, does the respondent eat: fruit, vegetables, whole wheat/rye bread, meat or fish (combined into a single index of consumption of nutritious food), sugary food, fried food (combined into a single index of non-nutritious food consumption)?

- Body Mass Index (BMI) at the time of the follow-up survey.

The independent variables in the regression analysis also included whether respondent was male, age and, of course, whether the person was in the intervention or comparison groups. Other independent variables included 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.

A full list of the independent variables is included in Table 2. Note that independent variables significantly associated with the dependent variable are highlighted with an asterisk. The model produced an r-squared figure of 0.654 which means that the model explained 65 per cent of the variation in the dependent variable (i.e. self-assessed vitality).

'Vitality' (generally feeling energetic and not tired) was positively associated with being male ($p < 0.05$). Being in the intervention group no longer significantly affected 'vitality'. None of the other variables used in the model – including all of the energy-efficiency devices – had a significant effect on 'vitality'.

Table 2 Regression analysis of the effects of various 'life style' behaviour upon self-assessed 'vitality'

Variable	**Standardised regression coefficient[1]**
Male	0.381*
General drinking	-0.278 ns
Drinking spirits	0.322 ns

Current smoker	0.112ns
Moderate exercise	-0.081 ns
Mild exercise	0.194 ns
Nutritious eating	0.193 ns
Non-nutritious eating	0.013 ns
Long-standing illness worse than a year ago	-0.211 ns
Age	0.124 ns
Body Mass Index (BMI)	0.128 ns
Intervention group[2]	-0.425 ns
Lagging jacket installed	***0.306 ns***
Loft, attic or ceiling insulation installed	***0.003 ns***
Wall insulation installed	***-0.121 ns***
Double glazing installed	0.247 ns
Door draught-proofing installed	***0.009 ns***
Window draught-proofing installed	***-0.213 ns***
Central heating controls or timer installed	0.141 ns
Low energy light bulbs installed	***-0.104 ns***
Index of no. of energy-saving devices	0.331 ns
Items in bold and italic relate to measures installed as part of the Warmer Homes Scheme.	

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

[1] Positive coefficient indicates better vitality

[2] Comparator is household in the comparison group

A regression analysis was also conducted on self-perception of general health. A full list of the independent variables is included in Table 3. Note that independent variables significantly associated with the dependent variable are highlighted with an asterisk. The model produced an r-squared figure of 0.370 which means that the model explained 37 per cent of the variation in the dependent variable (i.e. self-assessed general health).

Table 3 Regression analysis of the effects of various 'life style' behaviour upon self-assessed general health

Variable	**Standardised regression coefficient[1]**
Moderate exercise	-0.588**
General drinking	-0.264*
Drinking spirits	0.403**
Nutritious eating	0.450*
Intervention group[2]	-0536**
Low energy light bulbs installed	***0.524****
Current smoker	0.003 ns
Mild exercise	0.066 ns
Non-nutritious eating	0.033 ns

Long-standing illness worse than a year ago	0.091 ns
Age	0.012 ns
Body Mass Index (BMI)	-0.089 ns
Male	0.189 ns
Lagging jacket installed	***0.173 ns***
Loft, attic or ceiling insulation installed	***0.197 ns***
Wall insulation installed	***-0.198 ns***
Double glazing installed	0.017 ns
Door draught-proofing installed	***0.069 ns***
Window draught-proofing installed	***-0.016 ns***
Central heating controls or timer installed	0.008 ns
Index of no. of energy-saving devices	-0.173 ns
Items in bold and italic relate to measures installed as part of the Warmer Homes Scheme.	

ns = Not significant, * = $p < 0.05$, *** = $p < 0.001$
1 Positive coefficient indicates better general health
2 Comparator is household is in the comparison group

Respondents' self-assessment of their general health surprisingly was negatively associated with moderate levels of physical activity, though nutritious eating was positively associated with health. Interestingly, self-assessed health is positively associated with drinking spirits, though negatively associated with the general consumption of alcohol.[2] In this case, the effect of one energy efficiency variable, the use of low-energy light bulbs, is positively associated with self-assessed health. In this latter multivariate analysis of respondents' self-assessment of their general level of health, the negative effect of being in the intervention group remains.

2 This latter result should be interpreted with caution. Respondents may have consumed more spirits if they felt better because they felt more capable of coping with strong drink, or the link may simply be an indirect measure of affluence – those who are better off can afford to buy spirits.

Perception of Health Status

At baseline, 51 per cent of respondents in intervention households described their health as either 'excellent' or 'good' compared with 74 per cent at follow-up (p<=0.001). Although the same pattern of response was recorded among comparison households (an increase of 12 percentage points in the proportion of respondents describing their health status as either 'excellent' or 'good' – up from 65 per cent to 77 per cent) this change reached a lower level of statistical significance (p<=0.05).

Use of Health Services

Another indicator of health status is how often respondents use various health services. Among intervention households there was a significantly different pattern of use reported at baseline compared with follow-up, with respondents at follow-up being significantly (p<=0.01) less likely to report visiting a doctor on more than one occasion (down from 84 per cent to 73 per cent). Among the comparison group there was no significant change in the pattern associated with visits to doctors.

Table 4 How often have you visited a doctor for any reason in the last year?

	Never	Once	More than Once
	%	%	%
Baseline Intervention	**6**	**10**	**84**
Follow-Up Intervention**	**3**	**24**	**73**
Baseline Comparison	**4**	**15**	**81**
Follow-Up Comparison	**7**	**21**	**72**
*** p<=0.05; **p<=0.01; ***p<=0.001**			

The above analysis was replicated for households with children, with no significant variations in the level of attendance at doctors by children in either intervention or comparison households.

In relation to attending hospital outpatient departments in the previous 3 months, there was a significant fall among the intervention group (down from 35 per cent to 20 per cent: p<=0.01), with no significant change among the comparison group (down from 25 per cent to 16 per cent). There were no differences in the proportions of children attending outpatient departments in either the intervention or comparison households at baseline compared with follow-up.

Among the intervention group attendance at A&E departments in the previous 3 months had not fallen significantly (down from 5 per cent at baseline to 1 per cent at follow-up). A similar pattern of response was recorded for the comparison group.

Table 5 In the last 3 months have you attended a Casualty (Accident and Emergency) department as a patient?

	%
Intervention Baseline	**5**
Intervention Follow-Up	**1**
Comparison Baseline	**2**

Comparison Follow-Up	2
* p<=0.05; **p<=0.01; ***p<=0.001	

In relation to hospital admissions in the previous year (i.e. as a day case, overnight or longer) there was no significant change in the levels reported among intervention households at baseline (10 per cent) and follow-up (15 per cent), with the same pattern evident for the comparison group (18 per cent at baseline compared with 11 per cent at follow-up). Note that there were no recorded differences in relation to children being admitted to hospitals in the previous year among intervention and comparison households between baseline and follow-up.

Although not statistically significant, seeking the advice of a pharmacist in the previous 3 months was more likely to be reported by intervention households at follow-up (21 per cent) compared with baseline (17 per cent), whereas the proportion of comparison households seeking advice from pharmacists in the previous 3 months had fallen significantly (down from 29 per cent at baseline to 18 per cent at follow-up: p<=0.05). In contrast, a greater proportion of intervention households at follow-up said that they had contacted a pharmacist for advice on behalf of their children (up from 43 per cent at baseline to 86 per cent at follow-up: p<=0.05), whereas there was no significant difference recorded among comparison households (53 per cent at baseline compared with 56 per cent at follow-up).

Limiting Long-Term Illness or Disability

All respondents were asked to indicate if they suffered from any long-standing disorders, diseases or illnesses. In the intervention households at baseline, most (62 per cent) respondents said that they did suffer with such conditions compared with 33 per cent at follow-up ($p<=0.001$). However, the same pattern of response, albeit at a lower level of statistical significance ($p<=0.05$), was recorded among comparison households, with 50 per cent reporting such conditions at baseline compared with 38 per cent at follow-up.

Although not statistically significant, there was a fall in the proportion of intervention households at follow-up who indicated that their children had long-standing disorders, diseases or illnesses (down from 50 per cent to 29 per cent), whereas there was no change reported among comparison households (6 per cent at both baseline and follow-up).

Among the intervention households there was a fall in the proportion of respondents at follow-up who indicated that they had long-term health problems associated with: heart attack (down from 10 per cent to 3 per cent, $p<=0.05$); high blood pressure/hypertension (down 25 per cent to 11 per cent, $p<=0.01$); other heart/circulatory problems (down from 14 per cent to 5 per cent, $p<=0.05$); problems with joints arthritis (down from 34 per cent to 8 per cent, $p<=0.001$); and headache (down from 12 per cent to 2 per cent, $p<=0.01$).

Table 6 Long-Term Health Problems by Study Group

	Intervention Baseline	Intervention Follow-Up	Comparison Baseline	Comparison Follow-Up
	%	%	%	%
Heart Attack	**10***	**3**	**6**	**9**
Stroke	**-**	**1**	**3**	**-**
Pneumonia	**2**	**-**	**2**	**-**
Asthma	**8**	**3**	**6**	**6**
Emphysema	**1**	**-**	**1**	**1**
High Blood Pressure/ Hypertension	**25****	**11**	**18***	**8**
Other Heart/Circulatory Problems	**14***	**5**	**10****	**2**
Other Respiratory Problems	**5**	**2**	**2**	**1**
Problems with Joints/Arthritis	**34*****	**8**	**51**	**54**
Depression	**8**	**6**	**4**	**2**
Headache	**12****	**2**	**1**	**2**
Disability (Physical or Mental)	**13****	**3**	**23**	**17**
*** p<=0.05; **p<=0.01; ***p<=0.001**				

Among the comparison group there were significant falls in the proportions of respondents reporting high blood pressure/hypertension (down from 18 per cent to 8 per cent, $p<=0.05$); and other heart/circulatory problems (down from 10 per cent to 2 per cent, $p<=0.01$).

Between baseline and follow-up the proportion of intervention households with at least one person with a long-standing illness, disability or infirmity fell by 30 percentage points, from 65 per cent to 35 per cent (p<=0.001), whereas the fall among comparison households was less significant at 13 percentage points (down from 62 per cent to 49 per cent, p<=0.01).

Health Behaviours

In both the baseline and follow-up surveys, respondents were asked about their health behaviour in relation to smoking, physical activity and alcohol use.

Smoking

Smoking prevalence among respondents in intervention households fell significantly, (p<=0.01) from 38 per cent to 22 per cent between baseline and follow-up, with no significant change among comparison households between baseline and follow-up (21 per cent and 23 per cent).

Physical Activity

In relation to physical activity, the average number of times per week that respondents in intervention households engaged in moderate physical activity (i.e. not exhausting, fast walking, tennis, badminton etc) increased significantly, from 0.9 times to 1.5 (p<=0.05), with no change among the comparison group. Indeed, the proportion of respondents in the intervention group taking mild exercise decreased from 82 per cent to 67 per cent (p<=0.05), with the proportion taking moderate exercise increasing from 21 per cent to 32 per cent (p<=0.05). There were no differences among either the intervention or comparison groups regarding strenuous physical activity (i.e. the heart beats rapidly, running, jogging etc) or mild exercise (i.e. minimal effort, yoga, golf etc).

A further indicator of physical activity is the amount of housework done by respondents. Between baseline and follow-up there was a significant increase in the proportion of intervention households engaged in heavy household work (i.e. washing floors and windows, carrying rubbish bags, vacuuming etc), from 75 per cent to 88 per cent (p<=0.01), whereas there was no change reported among the comparison group (86 per cent at baseline and 87 per cent at follow-up). However, when asked to comment on how physically active they felt, there was no significant change in response between baseline and follow-up for intervention households (62 per cent vs. 65 per cent), whereas the proportion of comparison households saying they were either 'very' or 'fairly physically active' increased from 61 per cent to 75 per cent (p<=0.05).

Alcohol Consumption

In relation to alcohol, there were no significant differences in regularity of consuming alcohol between baseline and follow-up for either the intervention or comparison samples.

Diet

Among the intervention households the only significant changes between baseline and follow-up were an increase in the daily consumption of meat, chicken or fish (up from 31 per cent to 53 per cent: p<=0.001), with a fall in the daily consumption of whole wheat or rye bread (down from 37 per cent to 12 per cent, p<=0.001). In contrast, there were no significant changes in diet reported among the comparison group.

Table 7 Daily Consumption of Different Food Types by				
	Intervention Baseline	Intervention Follow-Up	Comparison Baseline	Comparison Follow-Up
Fruit	34	33	31	32
Vegetables	44	53	40	38
Sugary Food	23	20	14	9
Fried Food	3	3	4	-
Whole Wheat or Rye Bread	37***	12	25	20
Meat, Chicken or Fish	31***	53	34	33
* p<=0.05; **p<=0.01; ***p<=0.001				

Body Mass Index Using Height and Weight

Body Mass Index (BMI) is a tool which can be used to indicate how healthy a person's weight is. BMI is calculated using this formula: (weight in kilograms divided by height in meters). The following guidelines are used:

- A BMI less than 18.4 indicates being underweight in relation to height
- A BMI between 18.5 and 24.9 indicates ideal weight in relation to height
- A BMI between 25 and 29.9 indicates over ideal weight in relation to height
- A BMI above 30 indicates obesity.

Among intervention households there was no significant change in the BMI of respondents between baseline and follow-up, with the same pattern evident for 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 both 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 a 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 67 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).

Shivering from Cold when outside on a Cold Winter's Day

At baseline, 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).

Conclusions

An analysis of the health-related data shows that at a descriptive level there is evidence which points to health improvement among intervention households who availed of the energy efficiency measures under the Warmer Homes Scheme. These indicators include a significant shift in the proportion of respondents in intervention households at follow-up (up from 51 per cent to 74 per cent) reporting that their health is 'good' or 'excellent', with a fall in the proportion of intervention respondents reporting a limiting long-term illness or disability (a fall from 62 per cent to 33 per cent). In relation to specific health conditions, the intervention group reported significant falls in the prevalence of health problems associated with: heart attacks, high blood pressure/hypertension, other heart/circulatory problems, problems with joints/arthritis, headaches, and disability (physical or mental). The reduction in level of arthritis is consistent with what was found in an evaluation of a fuel poverty programme in Northern Ireland (Shortt and Rugkåsa, 2007) as well as improvements in general physical functioning reported by the Scottish Executive in an evaluation of the Central Heating Programme in Scotland (2007).

Although comparison households also recorded a significant increase in the number of energy efficiency measures installed, at a descriptive level the improvements in specific health conditions were less marked, with these households reporting improvements only in relation to high blood pressure/hypertension and other heart/circulatory problems.

In relation to self-reported heath status as measured by the SF-36, the results are less conclusive. Although at a descriptive level there is evidence of improvements to vitality and general health among the intervention sample, these differences were not sustained when other lifestyle factors were controlled for. These findings are consistent with research undertaken by the Scottish Executive to assess the health impacts of the Central Heating Programme in Scotland which found that the 'SF-36 may be relatively insensitive to changes in health associated with non-clinical interventions' and that changes in health status may only emerge over longer periods of follow-up. A study in Lambeth (Winder and Armstrong, 2003) which evaluated the impacts of central heating on older people arrived at a similar conclusion, with the authors again referring to the insensitivity of the SF-36 as well as the effect of a small sample size and a relatively short follow-up period. It may be that to fully understand the impact of the programme on health status further research is required to determine any longer-term impacts.

In terms of use of health services, there is some evidence at a descriptive level which suggests that those households who participated in the Warmer Homes Scheme are less likely to use health services. This group at follow-up were less likely to report visiting a doctor on more than one occasion in the previous year, with a similar trend recorded for attending hospital outpatient departments.

In relation to health behaviours, smoking prevalence between baseline and follow-up among the intervention group fell significantly, with no difference recorded among the comparison group. There was a significant increase in the level of moderate physical activity reported by the intervention group, with no change among the comparison group. Finally, the intervention group at follow-up were more likely to report eating more meat, chicken or fish, and less likely to report eating whole wheat or rye bread. Again there were no changes recorded among the comparison group.

Taken collectively, these findings at a descriptive level show that households availing of interventions under the Warmer Homes Scheme appear to have registered a greater range of health improvements, relative to comparison households. Although the results from using the SF-36 to measure health status are less conclusive, it may be that a greater period of time between baseline and follow-up is required for this instrument to register change be it either positive or negative. Future research in this area could explore the impact of a longer period between baseline and follow-up on the sensitivity of instruments used to measure self-reported health status. In addition, it may be possible for future studies to explore the potential of accessing individual patient records to monitor changes in health status and drug prescribing patterns as assessed by GPs and other primary health care professionals. This of course would require the consent of participants as well as the support of health professionals in providing the necessary data.

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Appendix (Output from Multivariate Analysis)

Model 1

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

Smoking status at baseline and follow-up
General drinking
Consumption of spirits
Avoids nutritious foods
Avoids non-nutritious foods
Engages in moderate physical activity
Engages in mild physical activity
Respondent age
Respondent Body Mass Index (BMI)
Self-reported health at baseline and follow-up
Lagging jacket installed
Loft insulation installed
Wall insulation installed
Double glazing installed
Door draft-proofing installed
Window draft-proofing installed
Low energy light bulbs installed
Central heating controls installed
Number of energy efficiency devices installed between baseline and follow-up

This model produced an adjusted R Square of 0.654 which means that the model explained 65.4% of the variation in the difference between general health at baseline compared with follow-up.

Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	2.153	30.139		.071	.944
	Smoking status at baseline and follow-up	.079	3.002	.003	.026	.979
	Perceived health at baseline and follow-up	5.352	8.301	.091	.645	.524
	Age	.273	3.162	.012	.086	.932
	Body Mass Index	-.472	.552	-.089	-.856	.399
	Male (dummy)	7.999	5.828	.189	1.373	.180
	General drinking	-8.580	3.957	-.264	-2.168	.038
	Consumption of Spirits	10.131	3.242	.403	3.125	.004
	Avoids nutritious foods	-13.027	5.665	-.450	-2.300	.028
	Avoids non-nutritious foods	-.687	2.996	-.033	-.229	.820
	Intervention group (dummy)	-27.090	7.987	-.536	-3.392	.002
	Moderate activity	-15.331	4.710	-.588	-3.255	.003
	Mild activity	1.788	3.422	.066	.522	.605
	Lagging jacket installed	7.957	8.312	.173	.957	.346
	Loft insulation installed	8.362	8.470	.197	.987	.331
	Wall insulation installed	-11.178	11.811	-.198	-.946	.351
	Double glazing installed	1.078	12.636	.017	.085	.933
	Door draft-proofing installed	3.144	7.504	.069	.419	.678
	Window draft-proofing installed	-.845	10.037	-.016	-.084	.933
	Low energy lt bulbs installed	25.138	9.151	.524	2.747	.010
	Central heating controls installed	.635	13.188	.008	.048	.962
	Number of energy efficiency devices installed between baseline and follow-up	-2.227	6.277	-.173	-.355	.725

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.891a	.794	.654	12.56458

ANOVAb

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18831.542	21	896.740	5.680	.000a
	Residual	4893.930	31	157.869		
	Total	23725.472	52			

Model 2

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

Smoking status at baseline and follow-up
General drinking
Consumption of spirits
Avoids nutritious foods
Avoids non-nutritious foods
Engages in moderate physical activity
Engages in mild physical activity
Respondent age
Respondent Body Mass Index (BMI)
Self-reported health at baseline and follow-up
Lagging jacket installed
Loft insulation installed
Wall insulation installed
Double glazing installed
Door draft-proofing installed
Window draft-proofing installed
Low energy light bulbs installed
Central heating controls installed
Number of energy efficiency devices installed between baseline and follow-up

This model produced an adjusted R Square of 0.370 which means that the model explained 37% of the variation in the difference in 'vitality' score between baseline and follow-up.

Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	-5.821	28.695		-.203	.841
	Smoking status at baseline and follow-up	2.438	2.859	.112	.853	.400
	Perceived health at baseline and follow-up	-8.813	7.903	-.211	-1.115	.273
	Age	2.023	3.010	.124	.672	.507
	Body Mass Index	.479	.526	.128	.911	.369
	Male (dummy)	11.397	5.548	.381	2.054	.048
	General drinking	-6.369	3.768	-.278	-1.690	.101
	Consumption of Spirits	5.710	3.087	.322	1.850	.074
	Avoids nutritious foods	-3.936	5.393	-.193	-.730	.471
	Avoids non-nutritious foods	-.182	2.853	-.013	-.064	.950
	Intervention group (dummy)	-15.151	7.605	-.425	-1.992	.055
	Moderate activity	-1.483	4.485	-.081	-.331	.743
	Mild activity	3.713	3.258	.194	1.139	.263
	Lagging jacket installed	9.960	7.914	.306	1.259	.218
	Loft insulation installed	.085	8.064	.003	.011	.992
	Wall insulation installed	-4.816	11.245	-.121	-.428	.671
	Double glazing installed	10.876	12.031	.247	.904	.373
	Door draft-proofing installed	.299	7.145	.009	.042	.967
	Window draft-proofing installed	-8.111	9.556	-.213	-.849	.403
	Low energy lt bulbs installed	-3.524	8.713	-.104	-.404	.689
	Central heating controls installed	7.991	12.556	.141	.636	.529
	Number of energy efficiency devices installed between baseline and follow-up	3.002	5.976	.331	.502	.619

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.790a	.624	.370	11.96281

ANOVAb

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7367.873	21	350.851	2.452	.011a
	Residual	4436.373	31	143.109		
	Total	11804.245	52			