# Living In Cold Homes After Heating Improvements: Evidence From Warm Front, England's Home Energy Efficiency Scheme.

CRITCHLEY, Roger, GILBERTSON, Janet <http://orcid.org/0000-0003-3338-7590>, GRIMSLEY, Michael and GREEN, Geoff



**Published version**

CRITCHLEY, Roger, GILBERTSON, Janet, GRIMSLEY, Michael and GREEN, Geoff (2007). Living In Cold Homes After Heating Improvements: Evidence From Warm Front, England's Home Energy Efficiency Scheme. Applied Energy, 84 (2), 147-158.

# LIVING IN COLD HOMES AFTER HEATING IMPROVEMENTS EVIDENCE FROM WARM FRONT, ENGLAND'S HOME ENERGY EFFICIENCY SCHEME

Roger Critchley [a], Jan Gilbertson [a], Michael Grimsley [a], Geoff Green [a,*]

And the *Warm Front* Study Group [b, c]

[a] Centre for Regional Economic and Social Research, Sheffield Hallam University, City Campus, Howard Street, Sheffield, S1 1WB, UK

[b] Public and Environmental Health Research Unit, London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, UK

[c] The Barlett School of Graduate Studies, University College, Gower Street, London, UK

[*]Address for correspondence:

Jan Gilbertson, Centre for Regional Economic and Social Research, Sheffield Hallam University, City Campus, Howard Street, Sheffield S1 1WB.

Tel: +44 (0)114 225 3539. Fax: 0114 225 2197

Email: J.M.Gilbertson@shu.ac.uk

**Abstract**

*Objective* To investigate explanatory factors for persistent cold temperatures in homes receiving heating improvements.

*Design* Analysis of data from a national survey of dwellings and households in England occupied by low-income residents receiving heating improvements or repair under the *Warm Front Scheme*.

*Methods* Over the winters of 2001-02 and 2002-03, householders recorded living room and main bedroom temperatures in a diary. Entries were examined for 888 households which had received high level heating interventions. 222 households were identified as occupying cold homes, with mean bedroom temperature below $16^0$C or mean living room temperature below $18^0$C. Binary logistic regression was used to model dwelling and household features and then occupants' behaviour and attitudes in the 'cold homes' sub-set compared with the remainder of the high intervention group. 79 supplementary, structured telephone interviews explored reasons given for lower temperatures. Using graphical and tabular methods, householders preferring cooler homes were distinguished from those who felt constrained in some way.

*Results* Cold homes predominate in pre-1930 properties where the householder remains dissatisfied with the heating system despite major improvements funded by *Warm Front*. Residents of cold homes

are less likely to have long-standing illness or disability, but more likely to experience anxiety or depression. A small sample of telephone interviews reveals those preferring lower temperatures for health or other reasons, report less anxiety and depression than those with limited control over their home environment. Their 'thermal resistance' to higher temperatures challenges orthodox definitions of comfort and fuel poverty.

*Key words:* Cold Homes; Preference; Comfort; Psychosocial health.

## Introduction

*Warm Front* is the UK government's main programme for tackling fuel poverty in English households, providing grant-funded packages of insulation and heating improvements. Though the scheme has significantly raised average indoor temperatures [1] a minority of recipients maintain relatively low temperatures. This paper explores two possible explanations, 'rational' or 'adaptive', modeled schematically as routes 1 and 2 in Figure 1.

A rational model suggests that low temperatures are explained by residual heating problems. Either *Warm Front* has not secured sufficient improvements in energy efficiency or recipient householders are unable to use the improved heating system effectively either because they find it difficult to operate[2] or because of the enduring financial constraints of fuel poverty. [3] The assumption here is of residents living below a human comfort zone defined by a heat balance model of the kind pioneered by Gagge [4] and Fanger. [5] Brager and Dear [6] describe the

deterministic logic underpinning such a model as '*physics → physiology→ subjective discomfort.*' Originally developed in a laboratory, such models assume 'that the effects of a given thermal environment are mediated exclusively by the physics of heat and mass exchanges between the body and environment.' In summary, comfort is a function of temperature; low temperatures imply discomfort.

However, residents may prefer their homes colder than these modelled comfort zones. As an alternative to the deterministic model, an 'adaptive' model can account for such preferences. Brager and Dear[6] offer 'the notion that people play an instrumental role in creating their own thermal preferences through the way they interact with the environment, or modify their own behaviour, or gradually adapt their expectations to match the thermal environment.' For Chappells and Shove[7] comfort is 'malleable construct,' either residents' acknowledge cold living conditions and respond with more clothing and/or by altering their pattern of daily living, or alternatively, they may feel comfortable with low temperatures as a result of thermal experiences and expectations.

These two models of comfort suggest differing consequences for the health of recipients living in cooler conditions. The UK government has chosen the 'rational' option in developing a Fuel Poverty Strategy, [8] [9] drawing on ample evidence of a direct physiological link between low temperatures and increased risk [10] [11] [12] of both circulatory and respiratory disease. A recommended minimum living room temperature of 18°C can be traced back to a scientific review of evidence on healthy living conditions by the European Regional Office of the World Health Organization.[13] Later the Building Research Establishment[14] and Brenda

Boardman in her influential work on fuel poverty[15] further distinguished health-related from comfort-related temperatures. The UK Fuel Poverty Strategy recommends 'standard' temperatures of 21°C in living rooms and 18°C in bedrooms to achieve comfort, automatically securing the lower threshold temperatures (18°C and 16°C respectively) for avoiding risk to health.

An ethical dilemma arises if occupants of objectively cold homes report acceptable levels of thermal comfort. According to proponents of the adaptive model, these occupants may be exercising a degree of personal control, suggesting a psychosocial route to health. There is evidence that perception of control influences comfort, ontological security [16] and health. [17] [18] [19] [20] However, older residents especially, may feel in control and comfortable at low temperatures yet expose themselves to physiological health risk. There is clear evidence that ageing is associated with diminished cold-induced thermoregulation. Impaired capacity to discriminate low temperatures [21] may lead to a reduction in body temperature. In extremis, such adjustment to cold stress, an inverted version of the 'boiled frog syndrome,' [22] can lead to hypothermia and death.

This article contributes evidence bearing on this ethical dilemma of choice verses risk. If choice is an illusion, heavily constrained by fuel poverty and building conditions, then the government has made a correct policy response to persistently low temperatures in some recipient households, enhancing the *Warm Front Scheme* by introducing more extensive measures to lift energy efficiency ratings. [23] If, on the other hand, low temperature is a genuine choice, then there is an ethical

dilemma when the risk to health is increased. We seek to quantify the balance of choice and constraint.

**Methods**

The study drew on a sample of 888 households in receipt new heating systems or significant heating repairs: a sub-set of 3489 households surveyed for a larger study of the *Warm Front Scheme* in five urban areas of England; Birmingham, Liverpool, Manchester, Newcastle and Southampton. University Ethical Protocols were followed for non-medical subjects. First wave surveys were conducted in the winter of 2001/2, a second wave in the winter of 2002/03, targeting dwellings both before and after *Warm Front* improvements.

Data relating to the household and home were collected by computer assisted interview. One person per household, usually the head of household or spouse, was invited to complete the interview which contained questions about the respondent's demographic characteristics, long-standing illness, on difficulty paying fuel bills, and on satisfaction with the heating system. It also included the twelve item General Health Questionnaire (GHQ12) the five item European Quality of Life Questionnaire (EuroQuol 5D) and the 36 item Short Form (SF-36). [24] [25] [26] Property data was collected by trained surveyors and energy efficiency calculated using a Standard Assessment Procedure devised by the BREDEM model. [27]

The seven-digit address postcode was used to link each dwelling to its Super Output Area of residence, the smallest areas for which census data is available in the UK, for which we obtained the 2004 Index of Multiple Deprivation (IMD) as a marker of

socio-economic status. The IMD is based on six area-based parameters: income; employment; health and disability; education and skills training; housing; and geographical access to services. [27].

For one to two weeks over the winters of 2001-02 and 2002-03, householders used temperature strips to record twice-daily living room and main bedroom temperatures in a diary. These entries were examined for the sample of 888 households in receipt of new heating systems or significant heating repairs. Of these post-intervention households, a subset of 222 was identified as still occupying cold homes, defined as those where either mean bedroom temperature over the measuring period fell below $16^0$C or where the mean living room temperature fell below $18^0$C.

A random sample telephone survey of 79 of the 222 respondents occupying cold homes was conducted using a structured set of questions about attitudes and behaviours. Responses were categorized thematically, distinguishing respondents constrained in some way by residual heating problems from those preferring or adapting to lower temperatures. A composite index was devised which calibrated respondents' preferences or constraints. A second index calibrated residents' confidence in operating various heating system controls. Further tabulation and exploratory statistical analysis was undertaken using the coded preference-constraint and confidence scores.

Binary logistic regression analyses were used to examine a range of factors potentially linked to cold homes, and in turn linking cold homes to health outcomes

(Figure 1). A series of models (Tables 1 to 3) progressively incorporated area and respondent demographic characteristics (model 1), the nature and condition of the dwelling, such as age, property type and characteristics associated with energy efficiency (model 2), household features associated with fuel poverty (model 3) such as income levels and difficulties paying fuel bills, occupants' satisfaction with home heating and their perception of thermal comfort (model 4), respondents' feeling of security (model 5) and self-reported levels of both mental and physical health and well-being (model 6) and long-standing illness or disability (model 7). The final model 8 incorporates the key explanatory variables associated with cold homes.

**Results**

Preliminary analysis of the data on post-intervention properties is consistent with a 'rational' explanation for low temperatures. Using the cold homes (not cold homes) outcome, Table 1 gives the adjusted odds ratios (ORs) and 95% confidence intervals for the initial model (model 1) on geographic area and individual respondent demographic characteristics.

Cold homes are least prevalent in Southampton which has the mildest climate of the five cities surveyed. Respondents from Birmingham, Liverpool, Manchester and Newcastle were, on average, around twice as likely to reside in cold homes. The oldest (OR: 0.34, CI 0.17 to 0.71) and White British (OR: 0.52, CI 0.31 to 0.86) respondents are significantly less likely to live in cold homes. Householders living alone are more likely to live in cold homes (OR: 1.54, CI 1.11 to 2.15) as are those living in areas of greatest multiple deprivation (OR: 1.31, CI 0.89 to 1.94). Demographic characteristics such as gender, educational qualifications, household

tenure or the presence of children in the household, were not significantly associated with cold homes.

Colder homes are also associated with certain in property characteristics (model 2). The newer the property, the less likely are their occupiers to maintain low temperatures (OR: 0.46, CI 0.27 to 0.77). Low temperatures are not as prevalent in dwellings with cavity walls (OR: 0.59, CI 0.42 to 0.83) and SAP ratings above 65 (OR: 0.54, CI 0.32 to 0.92) but more prevalent where there are draughts (OR: 1.43, CI 1.02 to 2.01) or condensation problems (OR: 1.32, CI 0.95 to 1.85). Cold homes are not significantly associated with household income and reported difficulty paying fuel bills (model 3).

Residents who are very satisfied with their accommodation generally (OR: 0.31, CI 0.31 to 0.73) and specifically with their heating systems (OR: 0.30, CI 0.14 to 0.62) are significantly less likely to live in cold homes (model 4, Table 2). Similarly those reporting higher levels of thermal comfort in the living room are less likely to live in cold homes (OR: 0.54, CI 0.22 to 1.28) and the association is significant in bedrooms (OR; 0.25, CI 0.11 to 0.58).

There are contrasting links with health status (Table 3). On the one hand, respondents with health problems clearly pre-dating *Warm Front* intervention are less likely to live in cold homes. Occupants with long-standing limiting illness are less likely (model 7) to maintain low temperatures (OR: 0.66, CI 0.47 to 0.94) as are (model 6) those reporting pain or discomfort on the EuroQuol scale (OR: 0.75, CI 0.53 to 1.06). In contrast, a variety of measures reveal a consistent association

between cold homes and poor psychosocial health. Using the SF36 dimensions, those with low social functioning are a third more likely to live in cold homes (OR: 1.36, CI 0.94 to 1.97) as are those with a low mental health score (OR: 1.38, CI 0.96 to 1.99). The link with poor mental health is reinforced by high scores on the GHQ12 scale (OR: 1.21, CI 0.83 to 1.76) and anxiety and depression on a EuroQol dimension (OR: 1.58, CI 1.11 to 2.26).

Though statistical analysis indicates ontological insecurity (model 5) dissatisfaction and stress as possible intermediaries between cold homes and poor psychosocial health, the results of the structured qualitative telephone interviews revealed more complex attitudinal and behavioural relationships with cold homes (Table 4). Only a quarter give a 'rational' explanation by explicitly citing residual heating problems. A few of these said the rooms were hard to heat; "The heating is on full and can't get it any warmer." For very few there were cost constraints; "I do like to be economical." However, a major residual problem was controlling the central heating system. A third of all respondents over 60 reported difficulty with programmers, with a majority of these saying they were too complicated; "I don't understand it," "I'm not very technical – unsure what to do." There were three types of response; first leaving the system as originally set, "I never touch the controls;" second, asking friends, family members or neighbours to adjust the setting; third, resorting to manual settings, "My husband switches it on when he gets up." However, in these cases, such coping strategies were evidently not successful in securing warm homes.

Attitudes to comfort were mixed. Despite living in cold homes, half the respondents acknowledged the value of a warm home, typically reporting "warmth makes you feel

better" and "it's a completely different house when heated – makes you comfortable; lifts you," confirming the results of our related in-depth qualitative study. [28] In some of these cases such dissonance between attitudes and behaviour can be explained by residual heating problems. In other cases, respondents had adapted to the cooler conditions in their previous homes and were only slowly adjusting to the possibility of higher temperatures; "I have never been used to heating upstairs," "You get acclimatized" and "I noticed the difference (after *Warm Front* measures) though I might have thought differently before I had central heating." Previous studies [29] [30] [31] provide evidence of 'thermal creep,' where perceptions of comfort are slowly 'adapted' to rising ambient temperatures made possible by energy efficiency measures. In this study, by way of contrast, the behaviour of a majority of respondents continued to reflect old attitudes. Despite the offer of a conventionally warm home, they 'adapted' ambient temperatures to match their preference for a 'cooler' home. "I can't sleep in a warm room" said one: "I like fresh air" and "Heating dries the air" reported two others, typifying concerns about air quality.

Perceptions of comfort and health were inextricably linked. "Cold kills the old" was one type of response to the question "Do you think a colder home is healthier than a warmer home?" However, for a quarter of respondents 'cool,' as distinct from 'cold' was perceived as good for their health (with another quarter unsure whether a cooler home was healthy or not). Typical responses were "Not a cold home but a cooler home, yes" and "Need a happy medium – I should know the answer to this, being a nurse" and "In olden days people seemed healthier when they didn't have central heating." For some respondents cooler conditions helped develop resilience to illness; "makes you hardier" and more immune from colds; "Definitely, my

brother's house is too hot. They are always getting colds." For others, warm homes were associated with poor ventilation and stuffy conditions: "I think it's bad to have the house too hot and sealed up." Many thought stuffy conditions 'harboured bugs and germs" which caused or reinforced asthma: "too warm breeds bugs – I think it causes asthma" and "too warm makes germs – best to have medium temperatures, not too stuffy."

Though the sample of 79 respondents is small, it is possible to distinguish a 'rational' group from an 'adaptive' group. Responses were categorized thematically; distinguishing those respondents constrained in some way by residual heating problems from those preferring or adapting to lower temperatures. A composite index was devised which calibrated respondents' preferences or constraints. Table 4 shows the results of exploratory statistical analysis, using coded preference-constraint and confidence scores.

Those who expressed a preference for low temperatures were less likely to live in an area of high deprivation or to have difficulty paying their heating bills, though their income levels were similar to the constrained group. They were also less likely to report condensation or draughts in their home and expressed greater satisfaction with their heating system. There was no clear pattern to limiting long-term illness but on two measures of mental health, (EQ-5D and SF-36) they reported less anxiety and depression. Though the sample size of 79 is too small to detect statistically significant differences between constrained and adaptive households, these results reflect differences detected between cold and warm homes in the larger sample of 888 households. Anxiety and depression are associated with both cold homes (in the sample of 888) and constrained households (in the sub-sample of 79). In contrast,

households *preferring* to occupy colder homes, report a level of mental health similar to those who occupy warmer homes.

**Discussion**

The *Warm Front Scheme* is a major component of government strategy to eliminate fuel poverty in England and enable even the poorest households to maintain healthy indoor temperatures. Yet exactly a quarter of our sample of 888 households in receipt of Scheme measures reported temperatures below the threshold set by the Government's Fuel Poverty Strategy.

A rational explanation assumes there are residual heating problems, either because *Warm Front* has not secured sufficient improvements in energy efficiency to provide affordable warmth, or because householders are unable to employ the improved heating system efficiently. There is some evidence to support these 'rational' propositions. Though over 90 per cent of cold homes have central heating, they tend to have been built earlier than the comparative group of warm homes and their occupants are more likely to report draughts and dissatisfaction with the heating system. Evidence from the 79 telephone interviews affirms some householders are living in cold homes because of economic constraints and a larger group, often older people, have difficulty controlling their central heating systems. Yet together this 'constrained' group is a minority, in the order of two fifths of those living in cold homes and overall one tenth of households in receipt of *Warm Front* measures.

A majority of telephone respondents report one of two forms of adaptation to low temperatures. About a fifth have adjusted their attitudes and behaviour to past or

present living conditions, in line with the coping strategies reviewed extensively in a study[32] of people in fuel poverty from North East England. However, in contrast, approximately two fifths of respondents living in cold homes prefer it that way, in effect adapting temperatures and behaviour to meet perceptions of thermal comfort and healthy living conditions. This runs counter to the trend of 'thermal creep' identified an earlier study, [33] and to evidence of rising indoor temperatures revealed by the Building Research Establishment and successive British House Conditions Surveys. In effect, this 'preference' group is offering 'thermal resistance' based on a mixture of past experience and current beliefs.

Certain relationships with health accord with the rational model. Generally, warmer homes are associated with better health, physical and mental. The exception is the group with limiting long-standing illness or disability; they also live in warmer homes, probably because they spend more time there than able-bodied residents (and despite evidence that those who spend more time at home are more likely to be in fuel poverty). [34] Other relationships accord with the adaptive model. Though in general colder homes are associated with poorer mental health, evidence from the limited number of telephone interviews suggests mental health is better where colder homes are preferred rather than endured.

**Conclusion**

Prima facie, headline evidence that a quarter of 888 recipients of high level energy efficiency measures still maintained low living room or bedroom temperatures, qualifies the success of the *Warm Front Scheme* operating when our surveys were undertaken in the period 2001-2003 and lends support for the enhanced version of

the scheme introduced in 2005. [35] For a significant minority living in cold homes, new provisions to raise energy efficiency levels beyond a certain threshold will help remove economic constraints to higher temperatures.

Yet for the majority living in cold homes, a nuanced approach to capability is required. User-friendly instruments and practical guidance would assist a significant, often, older group of those who report difficulty handling the controls of their heating systems. More fundamentally, the whole concept of a comfortable and healthy home is called into question by the beliefs and attitudes of those who prefer a cooler home. The elements of temperature and ventilation, the correlate of relative humidity and the consequences of damp and mould, are reviewed in an earlier paper by the *Warm Front* Study Group.[36] As respondents in this study correctly perceive, a balance of temperature and ventilation produces living conditions conducive to health. The challenge is to convey the range of tolerable living conditions to the most vulnerable sections of the population, especially to those who feel comfortable with temperatures low enough to present a risk to health.

## Members of the Warm Front Study Group

*Bartlett School of Graduate Studies, University College London*

| | |
|---|---|
| Sung H Hong | Research Fellow |
| Tadj Oreszczyn | Professor |
| Ian Ridley | Lecturer |

*Sheffield Hallam University*

| | |
|---|---|
| Roger Critchley | Visiting Research Fellow |
| Jan Gilbertson | Research Fellow |
| Geoff Green | Professor of Urban Policy |
| Mike Grimsley | Senior Lecturer |
| Bernadette Stiell | Research Associate |

*London School of Hygiene & Tropical Medicene*

| | |
|---|---|
| Ben Armstrong | Reader |
| Zaid Chalabi | Lecturer |
| Jack Dowie | Professor |
| Shakoor Hajat | Lecturer |
| Emma Hutchinson | Research Fellow |
| Megan Landon | Research Fellow |
| Wendy MacDowell | Research Fellow |
| Maryjane Stevens | Consultant |
| Nicki Thorogood | Senior Lecturer |
| Paul Wilkinson | Senior Lecturer |

*National Centre for Social Research*

| | |
|---|---|
| Richard Boreham | Research Director |

**Acknowledgements**

This study was undertaken as part of the national evaluation of the *Warm Front Scheme* (England's home energy efficiency scheme). It was supported by the Department of Environment Food and Rural Affairs (Defra) and the Welsh Assembly Government under contract to the Energy Saving Trust (EST contract number M47). The views expressed in this paper are those of the authors and not necessarily those of the funding departments. Paul Wilkinson is supported by a Public Health Career Scientist Award (NHS Executive, CCB/BS/PHCS031).

**References**

1. Oreszczyn T, Hong SH, Ridley I, Wilkinson P, The Warm Front Study Group. Determinants of winter indoor temperatures in low income households in England. *Energy and Buildings* 2006; 38,3: 245-52.

2. Yelding D, Girdlestone N, Etchell L. *Taking control: a guide to buying or upgrading central heating controls.* London: Ricability; 2004.

3. Healy JD, Clinch JP. Fuel Poverty, thermal comfort and occupancy: results of a national household survey in Ireland. *Applied Energy* 2002; 73:329-343.

4. Gagge AP, Solwijk JAJ, Hardy JD. Comfort and thermal sensations and associated responses at various ambient temperatures. *Environmental Research* 1967; 1,1: 1-20.

5. Fanger PO. *Thermal comfort.* Copenhagen: Danish Technical Press; 1970.

6. Brager GS, De Dear RJ. Thermal adaptation in the built environment: a literature review. *Energy and Buildings* 1998; 27:83-96.

7. Chappells H, Shove E. *Comfort: a review of philosophies and paradigms.* Centre for Science Studies, Lancaster University; 2004.

8. Department of Trade and Industry. *UK Fuel Poverty Strategy.* London: DTI; 2001.

9. Department of Environment, Food and Rural Affairs. *Fuel poverty in England: the Government's plan for action.* London: DEFRA; 2004.

10. Goodwin J. Cold stress, circulatory illness and the elderly. In: Rudge J, Nicol F, eds. *Cutting the cost of cold: affordable warmth for healthier homes.* London: E&FN Spon; 2000, p.48-61.

11. Collins K. Cold, cold housing and respiratory illnesses. In Rudge J, Nicol F, eds. *Cutting the cost of cold: affordable warmth for healthier homes.* London: E&FN Spon; 2000, p.36-47.

12. Wilkinson P, Landon M, Armstrong, B, Stevenson S, McKee, M. *Cold comfort: the social and environmental determinants of excess winter death in England, 1986-1996* York: Joseph Rowntree Foundation; 2001.

13. WHO. *Health impact of low indoor temperatures.* Copenhagen: World Health Organization; 1987.

14. Raw G, Aizlewood C, Hamilton R. *Building regulation, health and safety.* Watford: Building Research Establishment; 2001.

15. Boardman B. *Fuel poverty: from cold homes to affordable warmth.* London: Bellhaven Press; 1991.

16. Hiscock R, Kearns A, Macintyre S, Ellaway A. Ontological security and psycho-social benefits from the home: qualitative evidence on issues of tenure. *Housing, Theory and Society* 2001; 18: 50-66.

17. Steptoe A, Appells A, eds. *Stress, personal control and health.* New York: John Wiley & Sons; 1989.

18. Syme SL. Control and health: a personal perspective. *Advances in Mind-Body Medicine* 1991; 7, 2:17-27.

19. Chandola T, Kuper H, Singh-Manoux A, Bartley M, Marmot M. The effect of control at home on CHD events in the Whitehall II study: gender differences in psychsocial domestic pathways to social inequalities in CHD. *Soc Sci Med* 2004; 58:1501-9.

20. Wilkinson P, Landon M, Armstrong, B, Stevenson S, McKee, M. *Cold comfort: the social and environmental determinants of excess winter death in England, 1986-1996* York: Joseph Rowntree Foundation; 2001.

21. Collins KJ, Exton-Smith AN, Doré C. Urban hypothermia: preferred temperature and thermal perception in old age. *Br Med J* 1981; 282:175-7.

22. Saunders T. *The boiled frog syndrome: your health and the built environment..* England: Wiley-Academy 2002, p.5. ('A frog jumps into a pot of water which is gradually being heated. As the water gets warmer, the frog adjusts its body temperature and continues to adjust to the increasing water temperature until ultimately, the frog gets boiled alive').

23. Department of Environment, Food and Rural Affairs. *Fuel poverty in England: the Government's plan for action.* London: DEFRA; 2004.

24. Goldberg D, Williams P. *The user's guide to the General Health Questionnaire.* Windsor: NFER-Nelson; 1988.

25. Kind P. The EuroQol instrument: an index of health-related quality of life. In: Spilker B, ed. *Quality of life and pharmacoeconomics in clinical trials. Second edition*. Philadelphia: Lippincott-Raven Publishers; 1996.

26. Ware J. Measuring patients' views; the optimum outcome measure. SF-36: a valid, reliable assessment of health from the patient's point of view. *Br Med J* 1993;306:1429-1430.

27. Office of the Deputy Prime Minister. *The English indices of deprivation 2004 summary (revised).* Neighbourhood Renewal Unit, ODPM; 2004.

28. Gilbertson J, Stevens M, Stiell B, Thorogood N. Home is where the hearth is: grant recipients' views of England's Home Energy Efficiency Scheme (Warm Front). *Soc Sci Med* 2006, In press.

29. Department of Environment. *English House Condition Survey 1986: Supplementary Energy Report.* London: DoE; 1991.

30. Department of Environment, Transport and the Regions. *English House Condition Survey 1996: Energy Report.* London: DETR; 2000.

31. Critchley R, Gilbertson J, Green G, Grimsley M. *Housing investment and health in Liverpool.* Sheffield: CRESR. Sheffield Hallam University; 2004.

32. Harrington BE, Heyman B, Merleau-Ponty N, Stockton H, Ritchie N, Heyman A. Keeping warm and staying well: findings from the qualitative arm of the Warm Front Homes Project. *Health Soc Care Community* 2005; 13,3: 259-267.

33. Critchley R, Gilbertson J, Green G, Grimsley M. *Housing investment and health in Liverpool.* Sheffield: CRESR. Sheffield Hallam University; 2004.

34. Department of Trade and Industry (annex 4a) *Energy - its impact on the environment and society.* London: DTI; 2005.

35. Department of Environment, Food and Rural Affairs. *Fuel poverty in England: the Government's plan for action.* London: Defra; 2004.

36. Oreszczyn T, Ridley I, Hong SH, Wilkinson P. Mould and winter indoor relative humidity in low income households in England. *Indoor and Built Environment* 2006; 15, 2:125-135.

Figure 1

Rational and adaptive routes

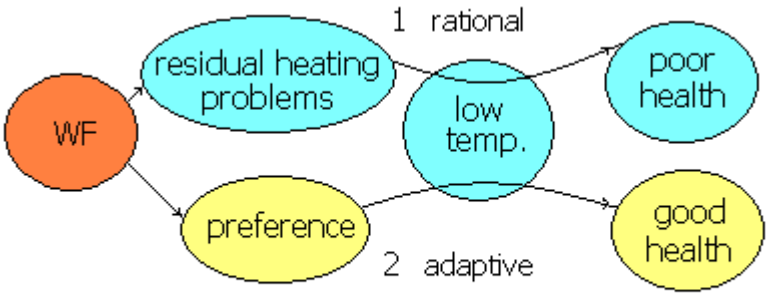

Table 1
Models 1 to 3 Outcome: Cold homes - adjusted odds ratios

**Model 1: Area, respondent and household characteristics (overall N = 879)**

| | N in model | OR (95% CI) [significance] | | N in model | OR (95% CI) [significance |
|---|---|---|---|---|---|
| *Study Area* | | | *Age* | | |
| Birmingham (ref) | 257 | 1.00 [0.04] | <44 (ref) | 189 | 1.00 [<0.01] |
| Liverpool | 110 | 1.15 (0.68 to 1.95) | 45-64 | 218 | 0.79 (0.43 to 1.45) |
| Manchester | 166 | 0.88 (0.55 to 1.40) | 65-74 | 250 | 0.50 (0.25 to 1.00) |
| Newcastle | 201 | 0.85 (0.53 to 1.35) | 75+ | 222 | 0.34 (0.17 to 0.71) |
| Southampton | 145 | 0.42 (0.23 to 0.76) | | | |
| White British | 783 | 0.52 (0.31 to 0.86) | IMD highest quartile | 175 | 1.31 (0.89 to 1.94) |
| Children <16 in household | 235 | 0.58 (0.31 to 1.06) | Social rent | 97 | 1.37 (0.83 to 2.25) |
| Single adult household | 395 | 1.54 (1.11 to 2.15) | | | |

**Model 2: Property characteristics (adjusted for model 1)**

| | | | | | |
|---|---|---|---|---|---|
| ***model 2a (overall N = 856)*** | | | ***model 2b (overall N = 879)*** | | |
| *SAP level* | | | *Year built* | | |
| <50 (ref) | 96 | 1.00 [0.07] | Pre 1930 (ref) | 304 | 1.00 [<0.01] |
| 50-64 | 249 | 0.68 (0.40 to 1.16) | 1930-65 | 444 | 0.54 (0.38 to 0.78) |
| 65+ | 511 | 0.54 (0.32 to 0.92) | 1966 on | 131 | 0.46 (0.27 to 0.77) |
| ***model 2c (overall N = 879)*** | | | ***model 2d (overall N = 879)*** | | |
| Cavity wall | 608 | 0.59 (0.42 to 0.83) | Condensation | 363 | 1.32 (0.95 to 1.85) |
| ***model 2e (overall N = 879)*** | | | | | |
| Draughty home | 311 | 1.43 (1.02 to 2.01) | | | |
| ***model 2f property omnibus (overall N = 879)*** | | | | | |
| *Year built* | | | | | |
| Pre 1930 (ref) | 304 | 1.00 [<0.01] | Draughty home | 311 | 1.49 (1.06 to 2.09) |
| 1930-65 | 444 | 0.53 (0.37 to 0.77) | | | |
| 1966 on | 131 | 0.44 (0.26 to 0.75) | | | |

**Model 3: Fuel poverty (adjusted for model 1)**

| | N in model | OR (95% CI) [significance] | | N in model | OR (95% CI) [significance |
|---|---|---|---|---|---|
| ***model 3a (overall N = 850)*** | | | ***model 3b (overall N = 875)*** | | |
| *Annual household income* | | | *Level of difficulty paying fuel bills in last year* | | |
| < £5200 (ref) | 202 | 1.00 [0.45] | Very easy (ref) | 152 | 1.00 [0.19] |
| £5200 - £10399 | 426 | 0.81 (0.54 to 1.23) | Fairly easy | 465 | 0.70 (0.45 to 1.08) |
| £10400+ | 222 | 0.71 (0.41 to 1.23) | Fairly difficult | 197 | 0.97 (0.59 to 1.61) |
| | | | Very difficult | 61 | 1.09 (0.54 to 2.17) |
| ***model 3c (overall N = 856)*** | | | | | |
| SAP 65+ | 511 | 0.73 (0.51 – 1.02) | | | |
| ***model 3d Fuel poverty omnibus (overall N = 852)*** | | | | | |
| Difficulty fuel bills | 249 | 1.25 (0.87 to1.80) | SAP 65+ | 509 | 0.74 (0.52 to 1.04) |

Table 2
Models 4 to 5 Outcome: Cold homes - adjusted odds ratios

**Model 4 Satisfaction, thermal comfort (TC) & home heating pattern (adjusted for model 1)**

| | N in model | OR (95% CI) [significance | | N in model | OR (95% CI) [significance |
|---|---|---|---|---|---|
| ***model 4a (overall N = 879)*** | | | ***model 4b (overall N = 879)*** | | |
| *Accommodation: satisfaction level* | | | *Home heating: satisfaction level* | | |
| Very dissatisfied (ref) | 26 | 1.00 [0.02] | Very dissatisfied (ref) | 39 | 1.00 [<0.01] |
| Fairly dissatisfied | 46 | 0.68 (0.25 to 1.86) | Fairly dissatisfied | 69 | 0.87 (0.38 to 1.98) |
| Neither | 33 | 0.60 (0.20 to 1.76) | Neither | 27 | 0.85 (0.30 to 2.41) |
| Fairly satisfied | 282 | 0.45 (0.19 to 1.05) | Fairly satisfied | 210 | 0.45 (0.22 to 0.95) |
| Very satisfied | 492 | 0.31 (0.13 to 0.73) | Very satisfied | 534 | 0.30 (0.14 to 0.62) |
| ***model 4c (overall N = 879)*** | | | | | |
| Heat rooms at different times | 186 | 1.93 (1.34 to 2.80) | | | |
| ***model 4d omnibus (overall N = 879)*** | | | | | |
| Accommodation dissatisfaction | 72 | 1.28 (0.69 to 2.37) | Home heating dissatisfaction | 108 | 1.91 (1.12 to 3.28) |
| Heat rooms at different times | 186 | 1.73 (1.18 to 2.53) | | | |
| ***model 4e (overall N = 484)*** | | | | | |
| *Living room am & pm modal thermal comfort* | | | *Bedroom am & pm modal thermal comfort* | | |
| (much) Too cool (ref) | 39 | 1.00 [0.12] | (much) Too cool (ref) | 56 | 1.00 [<0.01] |
| Comfortably cool | 48 | 1.28 (0.49 to 3.35) | Comfortably cool | 100 | 0.54 (0.25 to 1.14) |
| Comfortable | 216 | 0.64 (0.28 to 1.48) | Comfortable | 241 | 0.29 (0.14 to 0.59) |
| Comfortably warm | 181 | 0.54 (0.22 to 1.28) | Comfortably warm | 87 | 0.25 (0.11 to 0.58) |
| ***model 4f omnibus (overall N = 485)*** | | | | | |
| Bedroom TC: too cool | 56 | 2.91(1.54 to 5.52) | Home heating dissatisfaction | 66 | 1.77 (0.91 to 3.43) |
| Heat rooms at different times | 106 | 1.65 (0.99 to 2.76) | | | |

**Model 5 Ontological security (adjusted for model 1)**

| | N in model | OR (95% CI) [significance | | N in model | OR (95% CI) [significance |
|---|---|---|---|---|---|
| ***model 5a (overall N = 876)*** | | | ***model 5b (overall N = 878)*** | | |
| *How safe out alone in area after dark?* | | | *How safe alone at home at night?* | | |
| Very unsafe (ref) | 254 | 1.00n [0.13] | Very unsafe (ref) | 36 | 1.00 [0.04] |
| A bit unsafe | 235 | 0.80 (0.52 to 1.22) | A bit unsafe | 73 | 1.41 (0.58 to 3.43) |
| Fairly safe | 294 | 0.65 (0.43 to 0.99) | Fairly safe | 378 | 1.04 (0.48 to 2.25) |
| Very safe | 93 | 0.56 (0.30 to 1.03) | Very safe | 391 | 0.69 (0.31 to 1.51) |
| ***model 5c (overall N = 875)*** | | | | | |
| *Ontological security level** | | | | | |
| Safe (ref) | 371 | 1.00 [0.05] | | | |
| Insecure | 410 | 1.41 (0.99 to 2.00) | | | |
| Unsafe | 94 | 1.77 (1.06 to 2.98) | | | |

*Safe = safe on both measures, insecure = safe on one measure, unsafe = unsafe on both measures.

Table 3
Models 6 to 8 Outcome: Cold homes - adjusted odds ratios

**Model 6 Self-reported health (adjusted for model 1)**

| | N in model | OR (95% CI) [significance | | N in model | OR (95% CI) [significance |
|---|---|---|---|---|---|
| ***model 6a EuroQol (overall N = 876)*** | | | ***model 6b EuroQol (overall N = 839)*** | | |
| Pain or discomfort | 522 | 0.75 (0.53 to 1.06) | EQ5D tariff score: Low | 210 | 1.41 (0.97 to 2.05) |
| Anxiety or depression | 257 | 1.58 (1.11 to 2.26) | | | |
| ***model 6c (overall N = 878)*** | | | ***model 6d (overall N = 842)*** | | |
| High stress | 265 | 1.23 (0.87 to 1.74) | GHQ12 score 4 or more | 195 | 1.21 (0.83 to 1.76) |
| ***model 6e SF36 (overall N =843)*** | | | ***model 6e SF36 (overall N =841)*** | | |
| Health preference index: Low | 220 | 1.45 (1.01 to 2.10) | Social Function: Low | 221 | 1.36 (0.94 to 1.97) |
| ***model 6f SF36 (overall N =843)*** | | | | | |
| Mental Health: Low | 204 | 1.38 (0.96 to 1.99) | | | |

**Model 7 Health conditions (adjusted for model 1)**

| | | | | | |
|---|---|---|---|---|---|
| ***model 7a (overall N =879)*** | | | ***model 7b (overall N =770)*** | | |
| Long-standing illness or disability | 612 | 0.66 (0.47 to 0.94) | Shortness of breath | 365 | 1.36 (0.95 to 1.95) |

**Model 8 Omnibus overall (adjusted for model 1) - overall N = 839**

| | | | | | |
|---|---|---|---|---|---|
| *Year property built* | | | *Ontological security level* | | |
| Pre 1930 (ref) | 286 | 1.00 [<0.01] | Safe (ref) | 357 | 1.00 [0.09] |
| 1930-65 | 427 | 0.54 (0.37 to 0.79) | Insecure | 394 | 1.37 (0.94 to 1.98) |
| 1966 on | 126 | 0.43 (0.25 to 0.75) | Unsafe | 88 | 1.73 (1.00 to 2.99) |
| EQ5D Anxiety or depression | 241 | 1.39 (0.94 to 2.05) | SF Health index: Low | 218 | 1.70 (1.10 to 2.62) |
| Long-standing illness or disability | 584 | 0.52 (0.35 to 0.78) | | | |

Table 4
Constrained and preference group scores

| | | Living Conditions | | | Deprivation | | Mental Health | |
|---|---|---|---|---|---|---|---|---|
| | N | % Cond'sn | % Draughty | % Dissatis. Heating | % High IMD | % Difficult Heat bills | % EQ-5D low | % SF-36 low |
| Constrained | 22 | 59 | 73 | 27 | 46 | 41 | 41 | 29 |
| Neither | 18 | 39 | 39 | 11 | 22 | 22 | 39 | 24 |
| Mild Pref. | 26 | 42 | 23 | 8 | 27 | 35 | 21 | 8 |
| Strong Pref. | 13 | 31 | 15 | 8 | 15 | 15 | 15 | 8 |