The effect of improving the thermal quality of cold housing on blood pressure and general health: a research note

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ABSTRACT

Objective: To examine the effect of improving the thermal quality of housing on blood pressure (BP) and general health.

Design: A before and after study comparing the changes of the intervention with controls.

Setting: Four blocks of flats in the Easthall area of Easterhouse in Glasgow.

Participants: Residents of the four blocks who agreed to participate.

Intervention: Two blocks of flats were upgraded from being cold, damp and mouldy to being comfortably warm, dry and mould free throughout.

Main outcome measures: Changes in BP, general health and financial status.

Results: In the intervention subjects, systolic and diastolic blood pressures fell very significantly ($p<0.000$). There was also an improvement in general health as reported subjectively, and as indicated by a reduction in the use of medication and in hospital admissions. In addition, there was a markedly reduced expenditure on heating costs and other previous expenses. There were no changes in the control subjects in any of these measures.

Conclusion: Improving the thermal quality of housing to eliminate damp and mould and produce a comfortable temperature throughout the house has a major impact on the health of the residents. There are also financial benefits for the residents, and indirectly for the NHS.

Wide inequalities in health between social classes persist.[1–11] Material deprivation is strongly linked with many common diseases,[12] including coronary heart disease (CHD) and respiratory problems. Identified socioeconomic factors include poverty or gross inequality of income,[2 6 13] cold and damp housing,[2 14–18] lack of education[9] and unemployment[2 13]; all of which are factors excluded in the 1995 government enquiry[19] into measures to combat "variations"[20] in health.

Many studies have shown that there have been health gains by improving housing with good heating or by installing heating or insulation.[21–24]

Cold stress, or index, is the combined effect of temperature, air movement (wind or draughts) and moisture (rain or damp).[25] Chronic or recurrent exposure to cold is associated with mental, respiratory and cardiovascular illnesses.[25] The physiology of the body reacts to alterations of status, and rapid change produces more response than slow change. Therefore, frequent change of cold index produces more stress than a steady state. Mortality due to CHD is linked more strongly with cold index than with dietary fat intake, smoking or hypertension,[26] and, geographically, CHD risk throughout the world is linked to climatic features of temperature, rain and wind and the variability of the climate.[14] In England, the effect of climatic factors on the incidence of CHD is greater than that due to socioeconomic gradient.[14]

Easthall is one of 15 communities within the Glasgow peripheral housing scheme of Greater Easterhouse, one of the post-war housing schemes built to rehouse people from the inner city slums in Glasgow. In the mid-1980s, the Easthall Residents Association (ERA), with the Technical Services Agency (TSA), surveyed the existing Easthall housing stock, and found it to be cold with very poor insulation, and consequent severe problems with condensation damp. Cracks developing in the outside walls resulted in penetrating damp, and there was also rising damp in some groundfloor flats. This constant damp resulted in growth of mould of varying degree, but totally covering whole walls in some flats and sometimes affecting carpets, furniture, soft furnishings and clothing, resulting in early disintegration of the affected items.

The ERA and the TSA developed a practical design package ("Heatfest") to improve the housing.[27 28] Specification included double skinning walls (to stop penetrating damp, for insulation and to prevent interstitial condensation), insulation, draught proofing, double glazing, gas central heating, solar panels, dual-purpose heat recovery system, and inclusion of front and back verandas within the internal living area of the flat. The ERA obtained a grant from the European Economic Community, for a demonstration project to evaluate the thermal improvement from the intervention, with Glasgow District Council providing the remaining 70% of the costs. Two blocks (36 flats) were selected by the TSA for the intervention with two similar blocks for controls. The residents in the intervention flats were transferred to alternative accommodation and returned to the same flat once upgrading was completed.

The ERA requested one of the authors (ELL) for advice on how to carry out research to examine the effect of the "Heatfest" upgrading intervention on blood pressure (BP), as a major indicator of risk of CHD and stroke.

METHODS

Subjects

Residents in the two blocks due for intervention and in the two blocks selected by the TSA as the control were approached to explain the purpose of

the study, and asked if they would be prepared to participate. It was emphasised that participants could withdraw at any time, if they so wished. As can be seen from table 1, in many flats only one member was prepared to participate. The main reason residents gave for non-participation was that the study would be of no benefit to them personally. Initially, 68 residents (42 intervention and 26 control) agreed to participate, but during the study many subjects, particularly from the control houses, moved away or withdrew from the study. Thirty-six residents (27 intervention and nine control) completed the study.

Procedure

Participants were visited at home. To minimise falsely high readings as a result of an unfamiliar investigator, BPs were recorded at regular intervals by two of the authors (MMcK and MS), who were residents known to the other tenants of the study blocks, using Omron automatic recorders to avoid interobserver and intraobserver error and lack of expertise. Three readings were taken on each visit throughout the year, and the lowest used for the study. For the before and after comparison the readings taken in February/early March were used to avoid seasonal variation in BP,[29] also recorded by MMcK and MS. Each reading was checked to ensure that it was in keeping with those taken from that subject, in particular the readings taken before and after the one selected.

Design

Readings of BP from residents of the intervention flats were taken before the houses were upgraded. These were compared with readings obtained after the residents returned to their original flat, with the residents having spent at least 1 full year in their flat after it had been upgraded. In the control group, initial readings were taken at the same time as from residents in the intervention flats, and these were compared with readings taken 1 year after all the intervention residents had been living in their upgraded flats for at least 1 year.

Two years after the end of the study, 75 intervention and 40 control residents, who had been in the same houses throughout the study, were asked "Can you make any comments about your health over the last 4 years. Has it remained the same or have any particular aspects deteriorated or improved?" They were also asked whether, during the period of the study, they had made any change in the amount they smoked, the amount of exercise they took or the quantity or type of food they ate. No attempt was made to alter the individual lifestyle health risk factors of smoking, diet and exercise. These were not discussed with the subjects until after the study was completed. The numbers are greater than those in the main study because they included all members of a family in each flat and occupants of flats who had not participated in the BP study.

Table 1 Breakdown of potential and actual numbers for the study, and reasons for withdrawal

	Intervention (2 blocks)		Control (2 blocks)	
	Flats	People	Flats	People
Total	36		36	
Unable to contact occupants	4		4	
Did not wish to participate	3		9	
Started in study	29	42	23	26
Completed study	19	27	7	9
Withdrawn because of youth	–	3	–	–
Moved house during study	7	9	10	10
Withdrew from study	3	3	6	7

Statistical analysis

Student's paired t-test was used to compare changes in the BP readings in the intervention group, and separately in the control group. Student's two-sample t-test was used to compare differences between groups in the "population" readings, and the changes in BP between the intervention and control groups.

RESULTS

None of the 75 residents in the intervention flats or the 40 residents in the control flats had made any conscious change in smoking, diet or exercise and there had been no changes in job status.

Pre-study baseline population readings

Single BP readings from residents in the intervention and control flats who did not continue in the study were combined with the initial readings from the intervention and control residents who completed the study. This gave approximate population values. In the analysis, males and females were divided into three general age groups: under 18, age 18–45 and over 45.

For BP, there was no difference between the intervention and control groups as a whole, for either systolic or diastolic pressures. Table 2 shows that there was no significant difference between males and females of the same age group. However, there was a significant increase in systolic ($p<0.001$) and diastolic ($p<0.01$) pressure between increasing age groups. There was no significant difference between the intervention and control groups when the same age groups were compared.

Before and after study

Blood pressure

There were no significant differences between the intervention and control groups in pre-study BPs, either systolic or diastolic. Nor were there any significant differences between the initial readings of the residents who completed the study and those who withdrew. This was true of both the intervention and control groups.

Table 3 shows that, in the intervention group, there was a very significant fall in both systolic ($p<0.000$) and diastolic ($p<0.000$) BPs. In the control group, there was a small non-significant ($p = 0.396$) rise in systolic pressure, and a small marginally significant ($p<0.011$) rise in diastolic pressure.

General health: health service useage and medication

Intervention

- *Cardiovascular*. Prior to the "Heatfest" intervention, one person had had five admissions to hospital in 3 years — three for myocardial infarction (MI) and two for heart failure. The next five winters, one the severest on record, in the intervention flat were completed with only two minor MIs and no admissions to hospital. This person volunteered the statement that he or she would have been dead if it had not been for the intervention flat.
- *Respiratory*. Of the 75 residents questioned, 74 stated that their own and their families' health had improved, with all ages reporting a decrease in upper respiratory tract

Table 2 Population blood pressure (BP) survey

Females	Means	SD	Males	Means	SD
(A) Age >45 (n = 13)			(B) Age >45 (n = 10)		
Systolic BP	161	17	Systolic BP	157	14
Diastolic BP	95	12	Diastolic BP	93	13
(C) Age 18–45 (n = 19)			(D) Age 18–45 (n = 12)		
Systolic BP	124	12	Systolic BP	128	13
Diastolic BP	76	13	Diastolic BP	77	8
(E) Age <18 (n = 3)					
Systolic BP	105	6			
Diastolic BP	55	8			

infections. The single exception, who reported no change in health but no deterioration, lived at the uphill end of a block in a ground floor flat with persisting problems with rising damp. Two preschool children had asthma, which, prior to the intervention upgrading, required treatment with inhalers including steroid. Within a few months of the change, both became medication and asthma free, and remained the same over a period of at least 4 years. One teenager with chronic asthma had been dependent on medication, including inhaled steroids, for years and attended hospital three times a month. Within a few months of the intervention, this person also became medication and asthma free, remained the same over a period of at least 4 years, and has not needed hospital treatment since moving back into the intervention home. One person with bouts of severe bronchitis every winter had none in the 4 years after moving back to the intervention flat. One person had lost time from work every year because of sinus trouble. Even washout of the antral sinuses had failed to improve the situation, but in the 4 years following return to the intervention flat this person had no sinus problems and no days off work.

- *Other*. Two people with arthritis were able to make major reductions in their medication following return to the intervention flats. One child with repeated attacks of diarrhoea and vomiting during his first year of life had only one episode (acquired at nursery) in 4 years since returning to the intervention flat.
- *Financial*. The residents reported that heating costs had decreased greatly from spending £35 per week to produce inadequate heating in only one room to £7 per week providing a comfortable temperature throughout the house, plus hot water (figures at 1990 values). There had been no increase in the rents charged.

Controls

The 40 residents all reported that there had been no improvement in health nor had there been any noticeable deterioration. Their financial costs were unchanged.

Table 3 Changes in blood pressure (BP)

Variables	n	Means	SD	SE mean	CI for difference	t test p value	Recorded values Max	Recorded values Min
Intervention								
Systolic BP								
Before	27	142.14	22.91	4.41			196	112
After	27	122.78	15.94	3.07		Paired	148	100
Difference	27	−19.36	14.51	2.79	−13.93 to −25.41	0.000		
Diastolic BP								
Before	27	85.07	15.15	2.92			113	66
After	27	73.22	11.99	2.23		Paired	93	50
Difference	27	−11.85	13.34	2.57	−6.57 to −17.13	0.000		
Control								
Systolic BP								
Before	9	140.00	14.59	4.86			163	117
After	9	142.78	18.51	6.17		Paired	169	126
Difference	9	+2.78	9.30	3.10	+9.8 to −4.37	0.396		
Diastolic BP								
Before	9	84.67	8.23	4.86			98	71
After	9	92.89	8.87	2.96		Paired	106	78
Difference	9	+8.22	7.48	2.49	+13.87 to +2.47	0.011		
Difference between intervention and control								
Systolic BP								
Intervention	27	−19.7	14.5	2.8				
Control	9	+2.78	9.30	3.1		Two sample		
Estimated difference		22.14			13.77 to 31.12	0.000		
Diastolic BP								
Intervention	27	−11.85	13.3	2.6				
Control	9	+8.22	7.48	2.5		Two sample		
Estimated difference		20.07			12.70 to 27.44	0.000		

DISCUSSION

Blood pressure

BP readings have a long history as a risk factor for CHD and stroke. The higher the systolic and/or diastolic pressure, the greater the risk.

The incidence of hypertension appears to be related to cold experience.[25] In acute exposure to moderate cold there is a marked rise in systolic and diastolic pressures, whereas, in control subjects kept warm during the same period, BP remains steady.[30] This suggests that BP is responsive to cold stress, and there is some evidence that repeated acute rises in BP can result in chronic hypertension.[14]

Several studies[31–33] suggest that lowering the BP should lower the risk of CHD and stroke (table 4). The results in this study (table 2), achieved without the use of drugs, suggest the possibility of a great reduction in CHD and stroke incidence in the intervention residents. The anecdotal case report would tend to support this.

The post-Second World War social class (SC) gradient of CHD in the UK was a complete reversal of the pre-war situation,[34] despite no change in the traditional risk factors (smoking, exercise and dietary fat intake) between the classes.[34] The epidemic of CHD in the UK started among SCs 1 and 2 in the 1930s.[35] This period followed the 1920s, when maids and servants became expensive and difficult to get. The large houses, with many large rooms and big windows, no longer had maids to light fires in every room before the owners got up in the morning. The housing had therefore changed from having a relatively uniform thermal environment throughout to a situation in which there were great temperature differentials between the rooms. During this period, SCs 4 and 5 were living in small, often stone built, cottages or flats with few, smaller rooms that were relatively easy to heat and, therefore, with small differences in inter-room temperatures. However, after the war SCs 4 and 5 were moved to housing schemes such as Easterhouse, where the thermal environment was much poorer with a constant change of temperature when moving from the living room to any other room, including the bathroom and bedroom, and there was often the problem of damp. The incidence of CHD in SCs 4 and 5 rose to exceed the incidence in SCs 1 and 2.[34] By contrast, the post-war housing occupied by SCs 1 and 2 was changing to houses with a uniform, stable thermal environment throughout owing to central heating, insulation, double glazing and so on. The fall of CHD in the UK from the 1980s, and from the 1960s in the USA, Canada, Australia and New Zealand,[36] coincides with the progressive adoption throughout the social classes of the thermal changes described for SCs 1 and 2 in the UK, that is, almost identical to the changes in the intervention housing.

The important factor seems to be reducing the temperature differential between the rooms rather then the absolute temperatures. Interestingly, accidental hypothermia in the elderly seems to be less likely if there is a relatively uniform temperature throughout the house, even if very low, for example 9–13°C, than if the living room alone is kept at the recommended temperature of 22°C.[37]

Respiratory illness

The findings in this study are similar to others.[21–24] Interestingly, the early residents recognised the relationship between cold housing and respiratory illness by nicknaming the flats ''pneumonia houses''.[27]

General

There are possible secondary health benefits, for example previously young children missed vaccination because of repeated colds and were therefore at risk from a number of preventable conditions, and older children were losing time off school.

Before the intervention, many families could afford to heat only one room and the whole family tended to eat and live in that room, putting great stress on family members with increased risk of family or individual breakdown or mental disorders. With the improved heating, people could use all the rooms. Children could study, warmly, away from the distraction of the television in the living room,[18] with possible implications for education, future employment, income and consequently health. All these factors should reduce demands on scarce NHS resources.

Health service useage and medication

It was obviously impossible for the trial to be ''blind'', which means the changes in subjective health will be contaminated. Nevertheless, the individual case reports of the changes in medication for asthma and arthritis, the reduction of hospital admissions for CHD, asthma and sinus problems, and the reduction in time off work from bronchitis and sinus problems all argue for a ''real'' effect.

Finance and comfort

Energy audits of the original flats showed that, in winter, people would have to spend £60 per week (figures at 1990 values) to achieve the recommended healthy temperature levels throughout, and to avoid the risk of condensation dampness.[28] Because of money problems, for most, only one room was heated (often inadequately) leaving the rest of the flat cold and damp. The poorest families, and the unemployed, had up to £35 per week deducted from social security benefits to cover heating costs. However, the intervention flat could be kept comfortably warm throughout for about £7 per week. There was also a constant, plentiful supply of hot water (within that cost). Previously, this

Table 4 Published effects of different blood pressures (BPs)

		SMR	Decreased incidence of CHD	Stroke
1. Population study [31]				
BP males	136/88	136		
	129/81	61		
BP females	137/84	147		
	129/77	50		
2. Controlling systolic BP to 140 mmHg [32]			25–35%	28–44%
3. Lowering diastolic BP by 5 mmHg [33]			21%	34%

CHD, coronary heart disease; SMR, standardised mortality ratio.

What is already known on this subject

Housing quality has a major impact on health.

What this study adds

Improving the thermal quality of housing to eliminate damp and mould and produce a comfortable temperature throughout the house by itself has a major impact on BP and, therefore, on the risk of CHD and stroke.

Policy implications

Improving the thermal quality of housing to eliminate damp and mould and produce a comfortable temperature throughout the house should be a universal priority. It will improve the health and finance of the occupants, and it will also provide work, and finance, for others. The costs would be offset by reduced costs to the NHS and reduced carbon dioxide emissions.

required the additional expense of using an electric immersion heater. The absence of damp and fungal growth will save money previously spent replacing clothes, carpets and furniture destroyed by mould. While evidence has shown that warmer and less humid housing may improve health,[21] the health benefits may disappear if housing costs rise.[21] The intervention changes produced such a large decrease in housing costs that the health benefit is likely to persist, with increased financial flexibility.

The winter excess of deaths from CHD, stroke and respiratory disease[29] disappeared in Finland as a result of improvement in housing.[38] With one in five houses in the UK (one in three in Scotland) badly affected by cold, damp and mould,[39] there is great scope for improvements in housing which would result in improved health and would create employment. Certainly, the most expensive way of tackling health inequalities is to leave underlying causes intact.[20] Wide introduction of the ''Heatfest'' thermal intervention could also have a big impact on carbon dioxide emissions and therefore an impact on global warming.

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REFERENCES

1. **Townsend P,** Davidson N, eds. *Inequalities in health. The Black report*. Harmondsworth: Penguin, 1982.
2. **Whitehead M.** *The health divide*. London: Health Education Council, 1987.
3. **Bobak M,** Marmot M. East–West mortality divide and its potential explanations: proposed research agenda. *BMJ* 1996;**312**:421–5.
4. **Ben-Shlomo Y,** White IR, Marmot M. Does the variation in the socioeconomic characteristics of an area affect mortality? *BMJ* 1996;**312**:1013–4.
5. **Wilkinson RG.** Divided we fall. *BMJ* 1994;**308**:1113–4.
6. **Power C.** Health and social inequality in Europe. *BMJ* 1994;**308**:1153–6.
7. **Department of Health**. *The independent inquiry into inequalities in health report*. London: Stationery Office, 1998.
8. **Smith GD,** Morris JN, Shaw M. The independent inquiry into inequalities in health. *BMJ* 1998;**317**:1465–6.
9. **Phillimore P,** Beattie A, Townsend P. Widening inequality of health in northern England, 1981–91. *BMJ* 1994;**308**:1125–8.
10. **Watt GCM.** All together now: why social deprivation matters to everyone. *BMJ* 1996;**312**:1026–9.
11. **UK Statistics Authority**. *Population Trends 86 (Winter 1996)*. London: HMSO, 1996.
12. **Eachus J,** Williams M, Chan P, *et al*. Deprivation and cause specific morbidity: evidence from the Somerset and Avon survey of health. *BMJ* 1996;**312**:287–92.
13. **Kaplan GA,** Pamuk ER, Lynch JW, *et al*. Inequality in income and mortality in the United States: analysis of mortality and potential pathways. *BMJ* 1996;**312**;999–1003.
14. **Lloyd EL.** The role of cold in ischaemic heart disease: a review. *Public Health* 1991;**105**:205–15.
15. **The Public Health Alliance**. *Housing & health in Scotland*. A report by the UK Public Health Alliance, Scotland. London: UKPHA, 1992.
16. **Platt S,** Martin C, Hunt S, *et al*. Damp housing, mould growth and symptomatic health state. *BMJ* 1989;**298**:1673–8.
17. **Martin CJ,** Platt SD, Hunt SM. Housing conditions and ill health. *BMJ* 1987;**294**:1125–7.
18. **Olsen NDL.** Prescribing warmer, healthier houses. *BMJ* 2001;**322**:748–9.
19. **Department of Health**. *Variations in health. What can the Department of Health and the NHS do?* A report from the variations subgroup of the Chief Medical Officer's Health of the Nation Working Group, Department of Health. London: DoH, 1995.
20. **Wilkinson RG.** ''Variations'' in health. *BMJ* 1995;**311**:1177–8.
21. **Thomson H,** Petticrew M, Morrison D. Health effects of housing improvements: systematic review of intervention studies. *BMJ* 2001;**323**:187–90.
22. **Howden-Chapman P,** Matheson A, Crane A, *et al*. Effect of insulating existing houses on health inequality; cluster randomised study in the community. *BMJ* 2007;**334**;460–4.
23. **Moore R,** McIntyre T, Roper K, *et al*. *English house condition survey: 1996 energy report*. London: Department of the Environment, Transport and Regions, 2000.
24. **Somerville M,** Mackenzie I, Owen P, *et al*. Housing & health: does installing heating in their homes improve the health of children with asthma? *Public Health* 2000;**114**:454–9.
25. **Lloyd EL.** *Hypothermia and cold stress*, London: Croom Helm, 1986.
26. **Gyllerup S,** Lanke J, Lindholm LH, *et al*. Cold climate is an important factor in explaining regional differences in mortality even if serum cholesterol and other established risk factors are taken into account. *Scott Med J* 1993;**38**:169–72.
27. **McCormack C.** From the fourth to the third world: a common vision of health. *Community Dev J* 1993;**28**:206–17.
28. **Technical Services Agency**. *Easthall CEC solar demonstration project*. Glasgow: Technical Services Agency, 1992.
29. **Douglas AS,** Allan TM, Rawles JM. Composition of seasonality of disease. *Scott Med J* 1991;**36**:76–82.
30. **Keatinge WR,** Coleshaw SRK, Cotter F, *et al*. Increases in platelet and red cell counts, blood viscosity, and arterial pressure during mild surface cooling: factors in mortality from coronary and cerebral thrombosis in winter. *BMJ* 1984;**289**:1405–8.
31. **Tunstall-Pedoe H,** Smith WCS, Crombie IK, *et al*. Coronary risk factors and lifestyle variation across Scotland: results from the Scottish Heart Health Study. *Scott Med J* 1989;**34**:556–60.
32. **He FJ,** MacGregor GA. Cost of poor blood pressure control in the UK: 62,000 unnecessary deaths per year. *J Hum Hypertens* 2006;**17**:455–7.
33. **Law M,** Waki N, Morris J. Lowering blood pressure to prevent myocardial infarction and stroke: a new preventive strategy. *Health Technol Assess* 2003;**7**(31):1–94.
34. **Anon**. Social class and ischaemic heart disease. *Lancet* 1981;**ii**:347.
35. **Cassidy M.** Coronary disease: the Harverian Oration. *Lancet* 1946;**ii**:587–90.
36. **Le Fanu J.** *The rise and fall of modern medicine*. London: Abacus, 2004: 328–37.
37. **Lloyd EL.** Hypothesis. Temperature recommendations for elderly people: are we wrong? *Age Ageing* 1990;**19**:264–7.
38. **Nayha S.** The cold season and deaths in Finland. *Nord Council Arctic Med Res* 1978;**37**:20–4.
39. **National Housing Forum**. *Papering over the cracks*. London: National Housing Forum, 1994.