CENTRAL HEATING INSTALLATION FOR OLDER, LOW INCOME HOUSEHOLDS: WHAT DIFFERENCE DOES IT MAKE?

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ABSTRACT
Older people are particularly vulnerable to adverse health effects of cold living conditions. Yet, in the UK, they are often least able to afford sufficient heating to achieve recommended indoor temperatures and most likely to live in hard to heat housing with inefficient heating systems. This study was designed to evaluate a local authority initiative to install central heating, in terms of improvements in comfort, warmth and self-reported health. The sample consisted of 210 tenants, aged 70 or more, who were offered free central heating installation. They were interviewed and their home temperatures were monitored using miniature data loggers. Preliminary results from 102 participants who were monitored concurrently through a cold period are compared, indicating reductions in temperature differences between rooms after heating installation. This is important, considering the health effects of 'thermal stress' on older people. Methodological issues are also discussed.

INDEX TERMS
Thermal conditions, Residences, Questionnaires and perception assessments, Measurement methods, Psychosocial factors

INTRODUCTION
Older people are particularly vulnerable to adverse health effects of cold living conditions. Yet, in the UK, they are often least able to afford sufficient heating and are most likely to live in poorly insulated housing with inefficient heating systems. High numbers of excess winter deaths among those aged over 65 are associated with these factors.

There are known physiological effects of cold on the older population. Collins (1986) has identified benchmark indoor temperatures for maintaining health: between 18°C and 24°C, there is no risk to healthy, sedentary people; below 16°C, resistance to respiratory infections may be affected; below 12°C, there is increased risk of cardiovascular events, due to raised blood pressure. Furthermore, sensitivity to extremes of temperature can be impaired with age, so that, if subject to cold, older people may not take appropriate avoiding action. Circulatory disease is exacerbated by 'cold stress', which results from fluctuations in temperature (Enquselassie *et al.,* 1993) and can arise from moving between warm and cold rooms. However, moving from a cold dwelling to the cold outside produces greater cardiovascular strain than going out from a warm house (Goodwin, 2000).

Increasing ownership of central heating (CH) has been linked with the declining numbers of excess winter deaths over recent decades but it has also been suggested that the spread of CH may not have benefited the most vulnerable groups (Raw and Hamilton, 1995). Recent research suggests that increased vulnerability to winter death from cardiovascular disease is

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linked to indoor temperature and thermal efficiency of housing (Wilkinson *et al*., 2001). Other work has shown an association between the lack of CH and higher risk of dying in winter but identifies the need to explore further the influence of socio-economic factors and other measures of housing quality (Aylin *et al.*, 2001).

Although CH ownership is associated with raised indoor temperatures (Shorrock *et al*., 1992), possession of CH does not guarantee that it is used or is affordable by householders, particularly if they are older, on low incomes and living in hard to heat homes. The 1996 English House Condition Survey (EHCS) found that 116,000 households (0.6%) who had CH did not use it. A disproportionately high number of these were local authority tenants or headed by a person over 60, nearly half of who gave the running cost as a reason (DETR, 2000). National surveys of older people in 1972 and 1991 showed some room temperatures had improved over the period, thought to be due to wider CH ownership, but significant numbers were still below recommended levels (Henwood, 1997).

In view of apparently varying attitudes to costs and the use of CH, it would be useful to know the likely extent of improved comfort (and, potentially, health) if it were installed for older, low income households who currently have none. This study was designed to evaluate a local authority initiative to install CH for older tenants, in terms of improvements in comfort, warmth and self-reported health. Taking a multi-disciplinary approach, temperatures experienced in homes with and without CH were compared with the results of interviews concerning quality of life and heating behaviour.

Previous studies of indoor temperatures and the use of CH have largely relied on spot temperature measurements, which, in the case of the EHCS, were limited to the living room and hall only, at the time of interview (DETR, 2000). Here, the availability of cheap data loggers allowed the use of continuous monitoring in several rooms over 3 months. Thus temperatures could be compared through similar cold periods and judged against earlier survey findings. The study aims also included looking at different aspects of measuring 'cold' homes in terms of known health effects of cold. Are there real increases in temperature, in view of the perceived potential for higher costs of heating, especially as other energy efficiency measures were not installed at the same time as the central heating?

METHODS

In 2001, the London Borough of Lambeth launched an initiative to provide free CH to all local authority residents, aged 70 or older. A study was set up to explore any effects of CH installation on room temperatures, health and well being of those accepting or refusing the CH offer. The research was conducted through structured questionnaires administered by two face-to-face interviews in the respondent's own home. Some participants (N=60) from the initial survey sample will be tracked over 2002, with repeated interviews and data collection.

All tenants in Lambeth Borough aged 70 or over, identified as without CH, (N=1181) were mailed a letter by the Council, which offered a free installation. They were simultaneously invited to take part in a study exploring the effects of heating on health. The reply rate to the local authority was fairly low (64%), but 45% of these respondents (344) showed an interest in taking part in research. A final sample of 210 were contacted and participated in the study.

The participants were interviewed and had home temperatures monitored at hourly intervals over a 3-month period. The 102 participants analysed here represent those monitored over the same 3-day spell of cold weather in April (mean outdoor temperature = 7.1°C; range = 5.0-

10.3°C), who were not excluded for other reasons (such as misplacement of a datalogger, or installation of a radiator too near to the logger) and for whom exact installation dates were known. By selecting this group, a comparative analysis of home temperatures could be made.

Each home had between 2 and 5 temperature loggers strategically placed, one each in the main living rooms, the main bedroom and the bathroom. If CH had been installed, one was also put on the radiator most used, to establish when the heating was being used. A questionnaire was administered at that time, and again when the monitors were removed, around 3 months later. A layout of each home was sketched and the orientation was recorded. External temperatures were monitored simultaneously with the indoor readings.

The questionnaires included information about how homes were heated and tenants' heating behaviour, a record of energy units used, their self reports of home warmth and heating, any concerns over the CH installation, any experiences of chronic health and the SF36 (a self-report measure of health), as well as a measure of quality of life (SEIQoL).

RESULTS

Table 1 illustrates the age group, gender and household type of the sample. Ages of participants ranged from 70.1 to 95.9 (mean=78.3; SD=5.6). Most described themselves as British, English, Scottish, Welsh or Irish (87%), while 13% came from ethnic minorities. Around half the sample (53%) lived in flats (6% lived in a bedsit), whilst maisonettes (20%) and terraced homes (21%) made up most of the other residences. The mean number of rooms (including a separate WC room) was 5.5 (range = 3-11: SD = 1.5). Exactly half the sample had CH put in prior to the cold monitored period, while the other half heated their homes by direct heat appliances, open fires, or a warm air system provided by a communal boiler over this period. Many complained that the latter system was inadequate, as it supplied only two areas of the home and was often difficult to control. Thus, for the purposes of this study, the homes heated from a communal boiler were viewed as a home without an independent adequate CH system.

Table 1. Age group, gender and household type

Age group	**Gender % (N)**		**Total** *% (N)*	**Household type: cohabitees % (N)**			**Total** % (N)
	M	F		*None*	*One other aged 60+ or < 16yrs*	*One or more <60yrs*	
70-74	55 (17)	45 (14)	100 (31)	71 (22)	13 (4)	16 (5)	100 (31)
75-79	40 (14)	60 (21)	100 (35)	63 (22)	23(8)	14 (5)	100 (35)
80-84	58 (14)	42 (10)	100 (24)	75(18)	17 (4)	8 (2)	100 (24)
85+	33 (4)	67 (8)	100 (12)	83 (10)	17 (2	0 (0)	100 (12)
Total	*48 (49)*	*52 (53)*	*100 (102)*	*70(72)*	*18 (18)*	*12 (12)*	*100 (102)*

Although most people (68%) said they thought their accommodation was 'good' or 'excellent', prior to the CH initiative, just over half (54%) reported that their heating was inadequate, with 65% complaining that they suffered from draughts at home, and 29% said that their heating could not cope with the coldest days. It is also interesting to note that while almost all (99%) the participants heat their living rooms, much fewer said they heated their bedroom (43%), their bathroom (25%) or their kitchen (31%). Over a third of the sample (38%) said that they worried about the cost of heating, and a third (34%) also said that they did not get outside as often when it was cold. Those who initially accepted the offer of CH reported higher frequencies of cold in most of their rooms.

Table 2 shows how the properties were categorised for warmth both by the mean whole house temperature (taken as the mean of all rooms measured) and by the variability of temperature differences between rooms. There was a significant difference ($\chi^2=16.3$, $df=5$, $p=0.006$) between the CH and non-CH homes in the distribution of warm to cold homes (Table 3). On the other hand, looking at the whole house mean temperature alone, the percentage of "warm" houses in each group was the same (47%), although there were more (but not significantly) "cold" homes in the non-CH (20%) than the CH group (8%) ($\chi^2=3.5$, $df=2$, $p=0.176$). The key distinction between the groups, therefore, arises from the between-room temperature range, which was typically greater in the homes without CH (the means (±SD) being 4.3 (±2.4)°C and 2.9 (±1.6)°C respectively) ($t=3.5$, $df=1,100$, $p=0.001$).

Table 2. Warmth of homes: definition for selected cold period (external average 7.1°C)

Mean whole house temperature*			Mean between-room temperature range**	
Warm	*Intermediate*	*Cold*	*Consistent*	*Variable*
≥19°C	≥16.5 <19°C	<16.5°C	<3°C	≥3°C

** Thresholds for preliminary analysis determined from inspection of data over differing cold periods*

*** Threshold = difference between temperatures recommended for living and bedrooms (21-18°C)*

Table 3. Comparative warmth of homes over the cold period by central heating status

Central heating status	Warmth of homes - **percentage** (N)						Total **%** (N)
	warm, consistent	*warm, variable*	*intermediate, consistent*	*intermediate, variable*	*cold, consistent*	*cold, variable*	
No CH	**12** (6)	**35** (18)	**8** (4)	**25** (13)	**14** (7)	**6** (3)	**100** (51)
CH	**27** (14)	**20** (10)	**27** (14)	**18** (9)	**2** (1)	**6** (3)	**100** (51)
Total	**20** (20)	**27** (28)	**17** (18)	**22** (22)	**8** (8)	**6** (6)	**100** (102)

Room temperatures were compared against the British Geriatrics Society recommended level for living rooms (21°C) and known thresholds for health. No significant differences were found between the numbers with and without CH with living rooms at higher than 21°C for more than 75% of occupied daytime hours (taken as 8am-11am and 3pm-11pm), or at less than 18°C for more than 50% of daytime hours ($\chi^2=0.2$, $df=1$, $p=0.664$; $\chi^2=0.01$, $df=1$, $p=0.767$). Although more bedrooms fell below 16°C for more than 50% of nighttime hours (12pm-7am) in the group without CH, the difference was not significant ($\chi^2=3.5$, $df=1$, $p=0.062$). There was, however, a significantly higher prevalence ($t=2.8$, $df=1,100$, $p=0.006$) of bathroom temperatures below 16°C for more than 50% of the whole 24-hour period in these homes (37%, as compared with 14%).

The contrast of temperatures experienced at bedtime (i.e., the difference between the living room and main bedroom over the period from 10pm to 12pm) was also analysed. Again, the mean (±SD) for homes without CH was significantly greater than for those with CH (2.9 (±2.6)°C and 1.9 (±2.4) °C respectively, $t=2.1$, $df=1,99$, $p=0.039$).

DISCUSSION

In 1978 a national field survey, using spot readings, found CH homes to be 3°C warmer than those without CH, (Hunt and Gidman, 1982). It also noted that low-income homes had a high between-room temperature range (over twice as high as in high-income homes) and that the

warmest rooms were the same as the coldest of the others. The Lambeth study, in contrast, found that mean whole house temperatures for homes with and without CH differed by less than 0.5°C and, in fact, the mean living room temperature was slightly higher for those without CH than for those with. On the other hand, most results point to the likelihood of greater temperature contrasts in non-CH than in CH homes. The fact that a high percentage of tenants without CH did not heat rooms other than the living room shows support for the latter results. Bathrooms, in particular, are a problem area, as it is widely recommended that they should be even warmer (22°C) than other rooms when in use (Critchley, 1997). However, one quarter of all homes had bathrooms that fell below the threshold temperature of 16°C for more than half of the time and only 45% ever recorded a maximum over 21°C.

It appears that if only one room is heated it is often kept at a higher temperature than might be found in a centrally heated home. This may be to compensate for the rest of the house being so much colder, but could also be due to the lack of control of the heat source. Hunt suggested that the respiratory effects of a rapid temperature change, such as can be experienced at bedtime, is particularly stressful (Hunt, 1997). Continuous monitoring allowed this change to be measured here and results indicate a greater likelihood of a sharp temperature drop in non-centrally heated homes. Together with the other emerging patterns of temperature variability, this could have serious implications for health, considering potential effects of 'cold stress' on both respiratory and cardiovascular conditions (as discussed by Critchley, 1997). Insulation levels and other factors that would affect temperature differentiation will be analysed against these findings in due course. The significance of early morning changes in blood pressure (Goodwin, 2000), suggests a further area of temperature analysis. The second winter data will allow investigation of the effect of initial bills on CH use.

It is evident that the current study has had to overcome some obstacles that studies of similar type have undoubtedly experienced. First, bearing in mind the reliance upon the Council for the heating intervention, flexibility of the methodology was necessary, so this precluded the use of a random controlled trial. Regular intersectoral communications were required, as the response to the CH offer was lower than anticipated and numbers further dwindled as some tenants proved not to qualify for heating installation, while others changed their minds. Some feared the disruption, while others realised that they would sacrifice some room space. CH uptake is a serious issue, as it may be that those most in need do not accept the Council's offer. Second, the insulation properties of the buildings and the building types varied widely. A drive to improve home insulation for tenants on government benefits meant that insulation work was being carried out for some, but at different times from the heating installation. Third, psychosocial factors may influence answers to some of the questions by this age group. The stated preferences of older people to maintain lower temperatures than may be regarded as comfortable could be to do with pride and a reluctance to admit an inability to afford more heating (Wicks, quoted by Henwood, 1997). Last, when interpreting mean home temperature measurement, it is important to be aware that the behaviour of residents varies widely - some being away for months at a time, others being at home for 24 hours each day and still others may have family members staying for long periods, which will inevitably affect their heating usage and home temperatures.

Despite some monitoring considerations, the method used is believed to be superior to that employed in many studies where representative one-off readings have been taken or where the respondent may have warmed up the home especially to receive the visiting researcher, for example. It has provided an insight into the great variation in temperatures that can be experienced among this older population.

CONCLUSION AND IMPLICATIONS

This study aimed to contribute to the greater understanding of links between health and temperature in homes without CH. Use of the dataloggers allowed measurement of the full range of temperatures throughout the home and the 24-hour period by comparison with a range of external temperatures. It provides evidence of the reality of temperatures experienced by older people on low incomes, indicating the extent to which many of these are lower than recommended levels for comfort and health. It demonstrates the fact that the main advantage of CH is to improve consistency of temperatures throughout a dwelling, as well as the overall house temperature.

The evaluation of quality of life and health responses has yet to be completed. However, in view of theories concerning health effects of thermal stress, the results presented support the argument for the potential health benefit of CH installation for older or other vulnerable residents. In terms of health impact assessment of heating improvements, the aspect of temperature variability could therefore prove to be the key indicator of improved thermal conditions, taken together with absolute temperature levels. The results also point to the greater advantage possible if insulation were to be installed, which would further reduce temperature contrasts as well as addressing tenants' concerns over heating costs.

ACKNOWLEDGEMENTS

Grant funding for the evaluation study was received from the Dunhill Medical Trust and the Special Trustees of Lambeth Southwark and Lewisham Health Authority.

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