LARES Book Chapter

A report for the World Health Organisation, Health and Housing section.

The effect of cold homes on health: evidence from the LARES study.

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January 2004

General Information Page

This chapter is submitted as part of the LARES book. The LARES study (Large Analysis and Review of European housing and health Status) had 4 main objectives
(http://ns.who.dk/Housing/Activities/20020711_1)
1. quantifying the existing impact of housing conditions on the health of the population in Europe through a large survey;
2. developing an instrument for national and local authorities to identify the health priorities and needs of the population in the area of housing;
3. developing the methodology for supporting the calculation of cost-benefit analysis in balancing housing rehabilitation schemes and health gains;
4. developing cooperation with local authorities on such topics as indoor air quality, excess winter deaths, immediate environment aspects of housing and communication strategies.

This survey generated 2 datasets covering 8 cities across Europe.
The eight cities are given below,
Forlì, Italy (September 2002)
Vilnius, Lithuania (November-December 2002)
Ferreira do Alentejo, Portugal (January 2003)
Bonn, Germany (February 2003)
Geneva, Switzerland (March-April 2003)
Angers, France (March-April 2003)
Bratislava, Slovakia (April 2003)
Budapest, Hungary (Summer 2003)
The combined datasets are organised in two ways, one by home with 3374 rows, with one row for each home and the response from the head of household only and the other with 8519 rows, one for each survey respondent with survey data attached to each record. The resulting dataset has 1155 columns of information for each respondent,.
The work formed helped support the action plan on children and environmental health for the June 2004 conference to European Ministers of Health and Environment.
http://www.euro.who.int/budapest2004

1 Introduction

Cold homes have been linked to poor health by many studies; the extreme example of this is the phenomenon of excess winter deaths (where more deaths are recorded between December and March than expected from the death rates in other months of the year)in . Some studies link particular health outcomes with temperature; one important study shows a minima in cardiovascular mortality at a daily mean temperature of about 20 degrees C and an increase in mortality both as the temperature drops from this point and also as it rises, (Wilkinson, Armstrong, Landon 2001). This relationship has been shown for many cities around the world with the minima consistently near 20 degrees, except for some tropical countries that have higher minima, (Healy 2003).

Research also indicates that heart attacks and strokes in particular are more prevalent during winter as opposed to during the summer. These health outcomes are strongly associated with poverty (Asplund 2003) but Wilkinson et al (2001) found that cold related mortality was greatest in the coldest homes. Healy found higher ratios of winter deaths to summer deaths in warmer climates than those of the coldest EU-14 countries (the highest was Portugal with 28% more deaths in winter months than summer, UK; 18%, Mean; 16%). Other health outcomes linked with cold homes includes the findings of Strusberg indicating that rheumatic pain is linked to climatic conditions, specifically humidity and temperature. (Strusberg and others 2002).

So, there is evidence linking cold homes with an increase in mortality. The underlying hypothesis of this chapter is that those living in cold homes also suffer more poor health. A plausible pathway for this is that those living in poverty are less able to heat and maintain their homes. This sets up a vicious circle where the occupiers can't afford to heat their home properly or to upgrade it sufficiently to reduce their fuel bills. The stress and worry of this situation as well as the physical consequences might be expected to have an effect on health long before the increased mortality outcome referred to in the literature. The work in this chapter presents evidence that could help decision makers act to help break this vicious circle; improving health as well as occupant comfort.

A home should be able to provide shelter from the elements, but poor insulation, poor heating system, and ill-fitting windows and doors, all can contribute to a cold home. Wilkinson et al [2001] found 5 major determinants of cold, indoor temperatures for UK properties; these are listed below along with their consequences.

- Age of dwelling (the older, the colder)
- Absence of, or dissatisfaction with, the heating system (more dissatisfied, more cold)
- Cost of heating the dwelling; (highest is colder)
- Low household income; (less is colder)
- Household size (smaller is colder)

Even some relatively warm homes can "feel cold" to some occupants. This reflects the fact that many factors affect an occupant's thermal sensation or "thermal comfort". Fanger (1970) states; "thermal comfort is that condition of mind that expresses satisfaction with the thermal environment". However, he also found that thermal comfort is dependent on six main environmental variables, air temperature, relative humidity, radiant temperature, air speed, clothing level and metabolic rate (activity level).

If the home is both cold and has high moisture levels a consequence can be mould and damp, the health effects of mould and damp are significant and important enough to be covered separately in another chapter.

This chapter presents the findings from the LARES survey as follows; firstly a description of the methodology used in the analysis is given. Then the main health effects; (considered in this

study), respiratory health, cardiovascular health, arthritis and mental health, are analysed with respect to aspects of the home. There is a discussion of the consequences of the results of the analysis and finally a consideration of improvements that could be applied to homes and thieir expected health benefit.

2 Methodology

Early in the design of the LARES survey a decision was taken that no physical measurements of the factors affecting thermal comfort would be made (temperature, humidity, ventilation rate)[1]. Direct estimations of these factors are also not possible, however, information regarding occupant perception of thermal comfort is available through some questionnaire responses. Table 2.1 indicates possible ways to estimate the different variables from the LARES survey

Table 2.1 Variables related to cold homes from the LARES survey

Required variable	Variables from LARES dataset
Indoor air temperature	Temperature complaints, heating system complaints
Indoor relative humidity	from mould and condensation questions
Air speed	from draughtiness and air tightness questions
Radiant temperature	information on insulation
Clothing level	Can be adaptive, so more worn if cold, difficult to use this variable
Metabolic rate	Older people can be less active so feel colder, age may be a factor

The effects of extreme heat weren't considered in this study, though this can be a significant health problem particularly amongst vulnerable people in summer, see Valleron 2004 for information about the heat wave related deaths in France 2003.

Some key variables remain unknown and will mean that most findings remain indicative. Most important amongst these variables is occupant behaviour; how do occupants "use" the building. Factors include opening frequency of doors and windows, cooking habits, use of extract fans and bathing habits, all of which influence ventilation rate, heating gains and moisture production, these, in turn, affect both internal temperatures and humidities.

As indicated in the introduction several health outcomes have been associated with cold homes. The LARES dataset was used to test some of these associations in detail. Three main physiological outcomes were selected and also one more attributable to mental health. The health outcomes are listed below.

- Any Cardio vascular illness
(Doctor diagnosed, hypertension, heart attack, strokes)
- Any Respiratory health problem
(Doctor diagnosed acute bronchitis, wheezing and whistling)
- Any Arthritis/rheumatic pain
(self-reported)
- Belief that certain health problems affecting mental health are related to dwelling (this is related to four questions in the survey that together can be used to generate a score for mental health called the SALSA score, see the chapter on mental health for more details)

Each of these four outcomes is affected by many variables. In many cases the main cause of various illnesses is known (for example age and smoking status) but the effect of minor variables is not known, the analysis techniques used here allow for investigation of these minor variables

[1] See Chapter ??.

excluding the influence of known variables such as gender or age. The size and range of this dataset allows analysis of the effect of these minor variables while compensating for the effect of these "confounding variables".

The variables used in the analysis are split into 5 separate blocks;
Personal
Household status
Perceived housing characteristics
Climate
City
The analysis aims to answer the question, "given a case where all other variables remain equal, are certain aspects of the home implicated or associated with a particular health outcome?"

Personal, Household and Perceived variables

The individual confounding variables used in the model are listed in Table 2.2.

Table 2.2 Variables used in the logistic regression model

Variable Type	Variable	Notes
Personal	Age	
	Gender	Some cases with no valid gender are excluded
	Height	
	Weight	
	BMI Adult	Not valid for Child age group
	Smoking status	
	Alcohol consumption	
	Exercise status	
Household status	(SES) Socio-economic status	See Socioeconomic status chapter
	Number of Inhabitants	
	SALSA Mental Health Indicator	Not valid for Child age group
	Fuel poor?	if >10% income spent on heating (definition of fuel poverty from Boardman 1991)
Perceived household characteristics	Problems with cold in winter or transient season?	
	Dissatisfaction with Heating system	
	Dissatisfaction with Thermal Insulation	
	Dissatisfaction with Draughtiness	
	Mouldy or damp home MOULD_SCORE	(see chapter on mould for details)

Climate

Climatic data is used as a variable to explain possible city-to-city differences. The climatic data was generated using the program Meteonorm 4, (Meteotest 1999). Air temperature, relative humidity

and absolute humidity were used in the model[2] . The more water present in the air, the higher the home temperature has to be to reduce relative humidity to below 70%, this is considered important to prevent mould growth, [Oreszczyn, Pretlove 1999].

The climate variables selected were those considered as being most important in determining the effect on indoor hygrothermal conditions during winter.

City

"City" is used in the analysis as a variable to compensate for cultural and population differences seen that may exist between populations of different cities. It is known for example that diet changes between cities by using City within the analysis the effect of unknown city-to-city differences can be compensated for, making the analysis more robust.

General Analysis Comments

Certain variables have been transformed from a 5 point scale to a binary variable, for example where respondents were asked to rate their dissatisfaction with their heating system, "often" or "permanent" were aggregated and compared with "never" or "seldom", the neutral cases were discarded. This allows the difference between occupants who were generally dissatisfied with their heating (for example) to be compared with the set who were generally satisfied. It also reflects how people answer questionnaires, it is sometimes difficult to separate people who responded 5 compared to those who responded 4 on a five point scale but the assumption here is that they were clearly different to those who responded 2 or 1.

Detailed analyses using the full health dataset with each health outcome as the dependent variable and the set of possible environmental variables were selected as the independent variables. The technique used was logistic regression. The program Statview (1998) was preferred over SPSS for ease of use. The model was tested with and without the blocks of variables mentioned in the previous sections and the effects of these blocks of variables on the dependent variables investigated and the overall model fit are considered and commented on.

For the health outcomes, no city had a particularly high prevalence of any one outcome, so it was not considered necessary to exclude a particular city from the analysis or to test the validity of the findings for each city in turn. However, Ferreira had an extreme incidence of mould, in part due to climate and to the high prevalence of homes with no heating system, so this city was been excluded from some analyses to ensure that any relationship found, was true with and without this city.

Age is an important factor for each health outcome; some of the health outcomes have a very different aetiology depending on age, so the overall model was split into 3 age groups[3]. Age was kept in the model, as there can be a variation, dependent on age, within each of these 3 age groups.

For each block of variables tested, the odds ratios and the 95% confidence intervals were calculated for each of 4 housing characteristic variables selected as most likely to be indicators of poor hygrothermal conditions. These are as below:

- Temperature cold in winter?
- Dissatisfied with Insulation?
- Dissatisfied with heating system?

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[2] Absolute humidity is a measure of the total amount of water in the air at a given time. Relative humidity is a ratio of the amount of water in the air at a given temperature compared to the maximum the air can possibly hold at that temperature expressed as a percentage.

[3] Age is split into 3 rather than any more groups to keep the numbers in each group high for each city. Adults are between 19 and 60, children are younger and seniors are older than adults.

- Dissatisfied with draughts?

The hypothesis tested is then; that people who find their homes to be cold are more likely to report having certain health symptoms.

3 Results

From the distribution of variables in the LARES dataset there are several points that are apparent, firstly the distribution of health symptom prevalence by city is was different for each health symptom, Bonn and Vilnius have had the highest prevalence of respiratory health problems, Bratislava and Vilnius have had the lowest prevalence of arthritic problems, Vilnius, Ferreira and Budapest have had the highest prevalence of cardiovascular problems. Comparison of the distribution of cardiovascular problems with that of occupants over 60 years old indicates indicated some similarities between the two groups. The distribution of smokers across the 8 cities is was very similar with an average of about 25%.

The distribution of "problems with cold in winter or transient season" showed Ferreira and Vilnius having the highest prevalence, however considering the mean temperature in winter; Ferreira was the warmest city and Vilnius the coldest. The explanation for this is that Ferreira is only cold for a short period of the year and most homes do not have central heating, indeed some do not even have windows.

A factor that is discussed in the chapter on Mould is Tthat the prevalence of mould is far higher in Ferreira than in any of the other 8 cities, this can be explained in part by the high absolute humidity for the city. In winter the air is relatively warm and can hold a higher level of moisture than in the other cities and as most homes had no central heating, if the indoor temperature dropped, condensation would form on the cold surfaces and provide ideal conditions for mould growth.

The results of all the analyses undertaken are presented in summary form in table 3.1. Individual analysis results are commented on in the following sections and conclusions are drawn from these analyses in the discussion section. The results cover each of the 3 age groups. All analyses with the CHILD age group exclude the body mass index (BMI) and the mental health variable SALSA, as these variables are not valid for this age group.

Summary of results

Table 3.1 presents a summary of all statistical analyses undertaken. Climate variables seem to produce similar effects to the City variable indicating that a large part of the difference seen between cities may be explained by climatic differences. All the analyses for Child age group do not include BMIADULT or SALSA as variables as these are not valid for this age group.

Table 3.1: Summary of all statistical analyses

FACTOR	AGE GROUP	HOUSING FACTOR, direction of effect, OR, (95% CI)	COMMENTS
Respiratory Problems reported	Child	2.1 times MORE prevalent if dissatisfied with heating system (OR:2.1, CI:1.0-4.38) 4 times LESS prevalent if dissatisfied with draughts (OR:0.25, CI:0.13-0.49)	No changes when tested with and without Ferreira, (city 3)

	Adult	None	No changes when tested with and with out (city 3) Ferreira and (city 4) Bonn[4]
	Senior	1.97 times MORE prevalent if house cold in winter (OR:1.97, CI:1.03-3.76) 2.39 times MORE prevalent if dissatisfied with insulation (OR:2.39, CI:1.07-5.36)	Relationship seen is slightly strengthened by excluding Ferreira, (City 3) from the analysis
Cardiovascular Problems reported	Child	N/A	Too few cases for analysis
	Adult	None	
	Senior	None	Positive association found with Mould_Score[5]
Arthritis Problems reported	Child	N/A	Too few cases for analysis
	Adult	None	
	Senior	1.92 times MORE prevalent if house cold in winter (OR:1.92, CI:1.16-3.16)	
Belief that mental health problems are related to dwelling (H_24 RC)	Child	7.7 times LESS prevalent if dissatisfied with insulation (OR:0.13, CI:0.02-0.99)	Positive association found with Mould_Score
	Adult	1.79 times MORE prevalent if house cold in winter Cold (OR:1.79, CI:1.07-2.98) 1.67 times MORE prevalent if dissatisfied with insulation (OR:1.67, CI:1-2.81) 1.82 times MORE prevalent if dissatisfied with heating system (OR:1.82, CI:1.14-2.91)	
	Senior	None	Positive association found with Mould_Score Almost significant association found with poorly rated insulation.

A more detailed discussion of each of these analyses is presented in the next paragraphs.

Respiratory Problems reported

Of the entire dataset, the following prevalence was reported by age group

Table 3.2: Prevalence of Respiratory symptoms

	No symptoms	Some symptoms	Total
Child	1399	201	1600
Adult	5147	458	5605
Senior	1104	210	1314
Total Count	7650	869	8519

[4] Bonn had a high prevalence of respiratory illness reported, Ferreira had the highest prevalence of mould

[5] See chapter on mould for definition of Mould_Score

CHILD
In all cases there was a strong negative relationship with draughts, interpreted as the draughtier a home is perceived the less likely children will suffer from respiratory symptoms. There was a slight positive relationship between poor heating system and respiratory symptoms. Further analysis shows that MOULD_SCORE was a significant variable. An explanation could be that when the home is cold and there is insufficient ventilation mould can be a problem. The analysis was tested with and without Ferreira, in no case were the results changed from significant to not significant or vice versa. However climate variables seemed to produce similar effects to the City variable indicating that a large part of the difference seen between cities may be explained by climate differences.

ADULT
None of the four housing factors chosen were found to be statistically significant in any of the combinations of variables. This was also tested without Ferreira and Bonn.

SENIOR
"Temperature cold in winter?" and "Dissatisfied with Insulation?" were both significant in explaining respiratory symptoms amongst the senior section of the population surveyed. The relationship seen was slightly strengthened by excluding Ferreira, from the analysis.

Cardiovascular Problems reported

Of the entire dataset, the following prevalence was reported by age group

Table 3.3: Prevalence of CVD symptoms

	No symptoms	Some symptoms	Total
Child	1587	13	1600
Adult	4755	850	5605
Senior	690	624	1314
Total Count	7032	1487	8519

As there were only 13 cases for the Child category with CVD problems the analysis was only carried out for Adults and Senior age groups.

ADULT
None of the four housing factors chosen were found to be statistically significant in any of the combinations of variables.

SENIOR
None of the four housing factors chosen were found to be statistically significant in any of the combinations of variables. Mould was found to be a statistically significant factor and is dependent on cold damp conditions, however this will be reported in the chapter on mould and health.

Arthritis Problems reported

Of the entire dataset, the following prevalence was reported by age group.

Table 3.4: Prevalence of Arthritis symptoms

	No symptoms	Some symptoms	Total
Child	1580	20	1600
Adult	4851	754	5605
Senior	684	630	1314
Total Count	7115	1404	8519

As there were so few reported symptoms for the CHILD category, this analysis is not reported.

ADULT
None of the four housing factors chosen were found to be statistically significant in any of the combinations of variables.

SENIOR
"Do you have problems with cold in winter" was the only factor found to be statistically significant in any of the combinations of variables.

Belief that certain health problems affecting mental health are related to dwelling (H_24 RC)

Of the entire dataset, the following prevalence was reported by age group

Table 3.5: Prevalence of Health belief type mental health symptoms:

	No symptoms	Some symptoms	Total
Child	1530	70	1600
Adult	5142	463	5605
Senior	1226	88	1314
Total Count	7898	621	8519

CHILD
The factor "dissatisfaction with insulation" was found to be just statistically significant.

ADULT
For adults "Temperature cold in winter?", "dissatisfaction with insulation?" and "Dissatisfied with heating system?" were significantly associated with the health symptom, however "dissatisfaction with insulation?" acted in the opposite direction from that seen for the case of Child.

SENIOR
"Dissatisfaction with insulation?" seemed important as the upper confidence limit was very high however it, like the other variables, was not significantly associated to the outcome in any of the tests.

4 Discussion

In this section the consequences of the results of the analysis are considered.

Four main areas of health symptoms were considered in this analysis, these are; a respiratory index (including acute bronchitis and wheezing and whistling), cardio-vascular problems (hypertension, heart attacks and strokes), arthritic pain and an indication of mental health problems. From the literature we expect colder homes to have a higher prevalence of these health complaints, some clear findings from this investigation appear to back up this hypothesis. It should be noted that the factors within the home that are used in this analysis are responses to questions asked by the surveyor to the head of household and these responses are used as in indicator of possible causes of cold homes, so that "dissatisfaction with insulation" is an opinion on the thermal qualities of the insulation and not necessarily an accurate assessment.

Respiratory symptoms were found to be linked in different ways to different housing factors for children and for seniors. Draughty homes are were linked to fewer symptoms while poor heating systems were related with increased prevalence of respiratory problems for children. For seniors, having problems with cold temperatures in winter and being dissatisfied with the homes insulation were both associated with increased prevalence of respiratory symptoms.

Cardio-vascular problems were strongly linked to age, weight and gender, but after compensating for these, only Mould_Score was found to be a factor from all the housing factors considered (see mould chapter elsewhere in this book for more details).

Arthritic problems were very strongly linked to age; however within the senior age grouping, "problems with cold temperatures in winter" were also significantly associated with arthritic problems. It is important to note that arthrosis, degeneration essentially due to age, was classified in the same category as arthritis, so this may have led to a confusing picture resulting from the analysis.

A clear factor that appeared in almost all analyses was the depression score (SALSA) this is discussed by others elsewhere in this book but it is worth mentioning here also. It is likely that those with ill health show indications of depression, but investigating the prevalence of "those that believe that their mental health symptoms are related to their home" showed some interesting findings. This variable was associated with problems with cold in winter, dissatisfaction with heating system, poor insulation and Mould_Score; all can be considered variables symptomatic of a cold home. Given that there exists a link between depression and health, it seems plausible to hypothesise that cold homes may increase depression and therefore possibly affect health further.

5 Recommendations for possible improvements

In this report the main hypothesis was that cold homes and also homes that are perceived as being cold are detrimental to human health, the data presented from the LARES study tend to back up this hypothesis.

This dataset allowed us to look in detail for particular factors that may be related to certain health outcomes. The dataset is important as it combines factors from different subject areas for a large number of respondents. There are questions of reliability about the dataset[6], which is inevitable for one covering such a wide geographical range, and also range of population. Despite these limitations and after compensating for age, gender, smoking status, socio-economic status, city effects and climate effects, significant associations have been found between health symptoms and housing factors.

Cold, damp homes are relatively simple to improve but require resources; the improvements may well improve the quality of living and also the health of the occupants. The weight of evidence presented in this chapter and others suggests that money spent on improving poor housing is likely to reduce money spent on dealing with health problems.

A recent study backing this finding shows that respiratory symptoms improve in new energy efficient homes (Leech et al 2004). The indication being that it is the improved living conditions that are responsible for improved respiratory health.

Actions taken to improve housing will be strongly specific to each city; this must be taken into account in implementing any improvements.

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