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Cold homes and mental health harm: Evidence from the UK Household Longitudinal Study

Amy Clair *, Emma Baker

Australian Centre for Housing Research, University of Adelaide, Australia

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ABSTRACT

Cold homes are associated with a range of serious health conditions as well as excess winter mortality. Despite a comparatively mild climate cold homes are a significant problem in the UK, with a recent estimate finding that over one-quarter of low-income households had been unable to adequately heat their home in winter 2022. The magnitude of cold housing in a country that benefits from a mild climate indicates indifference towards, or acceptance of, a significant minority of people living in inadequate conditions on the part of policy makers. Cold homes are therefore a source of social harm. Recent changes to the household energy price cap, the rising cost of living, the ongoing effects of the benefit cap, and below inflation uprating to social security benefits is likely to greatly exacerbate this issue. In this research we use data from the UK Household Longitudinal Study to explore whether living in a cold home causes mental health harm. We control for mental distress and housing temperature on entry to the survey in order to account for the potentially bi-directional relationship. Multilevel discrete-time event history models show that the transition into living in a home that is not suitably warm is associated with nearly double the odds of experiencing severe mental distress for those who had no mental distress at the beginning of the survey; and over three times the odds of severe mental distress for those previously on the borderline of severe mental distress. These results show the significant costs of failing to ensure that people are able to live in homes in which they are able to live comfortably by even the most basic standards. These costs will be felt not just individually, but also more broadly in terms of increased health spending and reduced working.

1. Introduction

1.1. Cold homes, fuel poverty, and health

Cold homes are associated with increased mortality and morbidity. Exposure to indoor cold increases risk of illness, particularly respiratory and circulatory illness, as well as exacerbating the symptoms of other conditions such as arthritis (Sherriff, 2016; Marmot Review Team, 2011). Cold homes are of particular concern in winter, and are thought to be one of the main causes of excess winter deaths (EWD) in the UK (ONS, 2022). There were approximately 63,000 excess winter deaths in England and Wales in winter 2020 to 2021 (although this number was likely exacerbated by the ongoing COVID-19 pandemic) (ONS, 2022). Excess winter deaths in the UK are higher than those in nearby, colder countries (Angelini et al., 2019). More broadly, cross-country analysis shows that countries with milder climates often experience higher levels of excess winter mortality than colder ones – the ‘‘paradox of excess winter mortality’’ (Gasparrini et al., 2015; Healy, 2003).

That deaths are higher in the UK than in colder countries shows that these deaths are likely preventable, and that the exposure to cold and its consequences are a result of “manufactured uncertainty”, where “individuals are at risk in their homes not because of adverse natural events (external risks) … but because social and economic structures are accepting of inequality and the potential for some members of the community to experience harm” (Daniel et al., 2021, pg 114). In this way cold housing is regarded as a social harm – a condition that curtails human potential and fulfilment of human needs (Gurney, 2021; Pemberton, 2016).

The social harm approach was developed from concerns that traditional criminology has failed to adequately account for harm, particularly state and corporate-caused harm, that is not considered criminal. This is in large part because of the emphasis on individual intent in traditional criminology, which overlooks harms caused by indifference and neglects structural factors, resulting in definitions of crime excluding some serious harms but including other, less serious events (Hillyard and Tombs, 2007; Tombs, 2020). By moving beyond these

* Corresponding author. Australian Centre for Housing Research University of Adelaide Adelaide, South Australia Australia.
E-mail addresses: amy.clair@adelaide.edu.au (A. Clair), emma.baker@adelaide.edu.au (E. Baker).

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limitations, the social harm approach is able to "encompass harms which are deleterious to people's welfare from the cradle to the grave" (Hillyard and Tombs, 2007), such as the impacts of cold homes, while acknowledging that harms are not randomly distributed across the population and that some are more likely than others to be part of the "harmed community" (Hillyard and Tombs, 2007).

The groundbreaking work of Craig Gurney has highlighted the potential of the social harm approach for exploring the harms experienced in and caused by the private realm of the home (Gurney, 2020, 2021; Tombs, 2020). Relevant particularly to the effects of cold homes, "the social harm approach … is able to capture harms that result when human flourishing is compromised by the denial of social resources necessary to enable the exercise of life choices" (Pemberton, 2016). To live in a suitably warm home is a basic and universal need (Harrington et al., 2005), one that is unattainable for a significant number of people in large part because of the retrenchment of social security, declining wages, and failure to regulate housing quality or affordability, nor to control energy prices. The social harm approach, therefore, recognises that cold weather is an external risk, but low incomes, poorly insulated homes, and unaffordable energy prices represent manufactured uncertainty due to the failure of policy makers to adequately respond to these risks (Hillyard and Tombs, 2007). Further, cold homes will expose many people to a potential combination of risks due to the broader precariousness in their lives. For example, private renters who ask for improvements to the thermal efficiency of their home or who ask for repairs to issues that affect temperature may be at risk of retaliatory (or revenge) eviction.

Acknowledging the social harm framework, cold homes exist due to a combination of the climate they are located within; the design, condition, and energy efficiency of the home; the heating appliances available, and the ability of householders to pay for energy costs (Daniel et al., 2019; Daniel et al., 2021; Pye et al., 2017; Marmot Review Team, 2011). One suspected reason for the higher exposure to indoor cold in the UK is the prevalence of old and inefficient housing stock which tends to be colder than newer homes (Marmot Review Team, 2011). There is also evidence of an 'inverse housing law' in the UK, akin to the inverse care law, with poorer quality homes (those that are less able to provide protection from cold weather) more common where the climate is colder, exacerbating the effects of cold weather (Blane et al., 2000; Mitchell et al., 2002; Tudor Hart, 1971). Contrastingly, the generally higher condition of social housing, which is subject to the Decent Homes Standard and allocated based on need, has historically positively interrupted the link between deprivation and cold homes (Marmot Review Team, 2011) an ability noted in other aspects of life associated with deprivation (Bradshaw et al., 2008).

A concern related to cold homes is that of fuel poverty, sometimes also referred to as energy poverty (although the two terms are used somewhat differently), or more recently "warmth & energy deprivation" (Kearns et al., 2019). Fuel poverty is often defined in relation to a household's ability to keep the home adequately warm (defined by the World Health Organisation as 21 °C in living rooms and 18 °C in bedrooms) for an affordable cost (Grey et al., 2017; Pye et al., 2017) – typically less than 10% of gross income (Gilbertson et al., 2012; Robinson et al., 2018; Marmot Review Team, 2011), although England has adopted a different Low Income Low Efficiency approach. Broader definitions refer to a household's ability "to attain the socially and materially necessitated domestic energy services that ensure the wellbeing of a household, allowing them to participate meaningfully in society" (Robinson et al., 2018).

The risk of harm caused by cold homes, as well as other elements of inadequate housing, belies the conventional perspective of home a place of safety (Bashir, 2002; Gurney, 2020, 2021). Mental health harms are one of the categories of social harm proposed by Pemberton (2016), and it is this form of social harm that we focus on in this paper. In noting the gaps in the field, the World Health Organisation's Healthy Housing Guidelines recommend that emerging research should focus on better understanding the mechanisms that link cold homes to health outcomes, such as 'psychological responses' (WHO, 2018). There are however, a number of potential causal pathways between cold homes and mental health indicated in the existing literature: stress associated with experiencing cold or financial strain (Curl and Kearns, 2017; Gilbertson et al., 2012), reduced psychosocial benefits of home including reduced feelings of autonomy and control over environment (Evans et al., 2003), effects on social life/isolation (Harrington et al., 2005), and effects on sleep (Angelini et al., 2019).

The need to increase spending on heating during cold(er) weather can be a significant source of financial strain. Financial strain is detrimental to health (Clair et al., 2016; Selenko and Batinic, 2011), disturbs sleep (Hall et al., 2008), while also squeezing potential spending on other essentials such as food - creating what has been termed the 'heat or eat' dilemma (Angelini et al., 2019). Those on low and fixed incomes are particularly at risk. For example, the 'energy cap', or maximum that energy suppliers can charge set by Ofgem, a non-ministerial government department, was increased to £1971 (or £2017 for those using pre-payment meters) from April 2022, up 54% from £1277. This significant rise is in stark contrast to the reductions in social security payments and freeze on the benefit cap. The year 2022 saw the biggest fall in unemployment support since benefit uprating (i.e., approximately yearly calculations about social security payment increases, began in 1972). This follows a period of near constant below-cost increases over the past 10 years, undermining the incomes of those who receive income support (Matejic, 2022). The benefit cap, which limits the amount of support households can receive, has remained unchanged since November 2016 and limits benefit income to £13,400 per year for a single-person household outside of London, meaning that fuel costs could account for up to 14.7% of income before housing costs (or 9.9% of benefit income for a couple or single parent household outside of London – benefit cap £20,000). For pensioners, the new benefit cap accounts for over 20% of the state pension at £185.15 per week (Gov.uk, n.d.).

A number of papers have explored the psychosocial benefits of home, particularly the potential of homes to create feelings of control and autonomy, as well as the benefits of security and consistency (Brown et al., 2022; Gibson et al., 2011; Gilbertson et al., 2012; Hiscock et al., 2001; Kearns et al., 2000). These benefits are undermined by housing problems including cold (Gilbertson et al., 2012; Kearns et al., 2000). Correspondingly, studies investigating the effects of improving the warmth of UK homes have previously found that by improving warmth, people felt 'more at home', less isolated (Sawyer et al., 2022), were able to expand the useable space in their homes, and experienced improvements in their emotional security (Gilbertson et al., 2006; Grey et al., 2017).

Some are more vulnerable than others to the effects of cold because of greater time spent in the home and/or greater difficulty managing body temperature (Robinson et al., 2018), while others are at risk of experiencing cold because of broader inequalities. Notably, older people (Angelini et al., 2019), children, stay-at-home parents (Evans et al., 2003) and those with certain long-term conditions (NICE, 2021; Marmot Review Team, 2011) spend more time in the home. Older people and people with certain long-term conditions will also have poorer thermoregulation increasing their risk. Policy concern for the impacts of cold housing on older people are reflected in policy interventions such as the Winter Fuel Allowance, which provides a tax-free unconditional cash transfer paid in a yearly lump sum for older (over pensionable age) households. Findings relating to the impact on health have been mixed (Angelini et al., 2019; Crossley and Zilio, 2018). Disabled people face higher energy costs because of heating needs and equipment use (Sangster et al., 2022). Evidence of the impact on housing on health more broadly indicates women are particularly negatively affected due to their increased time spent in the home because of the persistence of gendered roles in home keeping and care, as well as the gendered effects of the cost-of-living crisis (Sangster et al., 2022; Vásquez-Vera et al., n.

d.).

These pathways all have the potential to influence mental health. Mental ill-health is one of the leading causes of disability worldwide: depression is ranked by the World Health Organisation as the largest contributor to global disability, estimated to affect 4.4% of the world population, while anxiety is the 6th largest (WHO, 2017).

1.2. Our contribution

We add to the literature on the impact of cold homes on health through the robust analysis of UK-wide longitudinal data, adding to the relatively smaller literature on mental health effects of cold, and covering the full range of adulthood rather than a particular age group. Further, recognising the lack of attention to gender (Vásquez-Vera et al., n.d.) in the existing literature, we explore the role of gender as a potential moderator in the relationship between cold homes and mental health harms. We also bring together the disparate housing and health literatures, recognised as a limitation in the knowledge base to date (Gurney, 2021). We explore not only the potentially negative impacts of cold homes on people with no mental distress at the time of entry to the survey, but also the effects of cold on people showing symptoms of mental distress to see whether, and to what extent, becoming unable to keep their home warm aggravates mental distress, potentially acting as a tipping point into severe mental distress (Baker et al., 2020). Our research questions are therefore:

- Who are the harmed community?; i.e.,. Who is it that lives in cold homes?
- What is the effect of transitioning into living in a cold home on the likelihood of reporting severe mental distress for those who previously reported good mental health?
- What is the effect of transitioning into living in a cold home on the likelihood of reporting severe mental distress for those who were previously symptomatic for poor mental health?

2. Data and methods

2.1. Data

This paper uses the UK Household Longitudinal Study (UKHLS, also known as Understanding Society) (University of Essex, 2021). The UKHLS began in 2009 with a survey of approximately 40,000 households. The adult survey collects data on all those in a household aged 16 or over on a range of topics, including health, housing and sociodemographics. Fieldwork periods vary between 12 and 24 months depending on respondent sample origin, but sample members are interviewed approximately annually. The most recent wave (11) was collected between January 2019 and December 2021. The UKHLS sample design is both stratified and clustered. Additional details about the data are available in the user guide (ISER, 2021) and the data are available to researchers via the UK Data Service. We limit the data to only those that entered the survey at wave 1 (2009–10), giving a consistent origin time for all participants. We further remove any unusually young (under 16) respondents, and, because of the longitudinal nature of our analysis, restrict the sample to those that had responded to at least 3 survey waves. The sample is further reduced to create two populations: 1) those that had low/no mental health problems and lived in warm homes at wave 1, and 2) those that had borderline mental health problems and lived in warm homes at wave 1. This approach enables us to explore the impact of transitioning into living in cold homes on health, rather than vice versa, given the potentially bidirectional relationship between housing and health (Mould and Baker, 2017).

2.2. Outcome: mental distress

The 12-item General Health Questionnaire (GHQ-12) is a widely used and validated, unidimensional measure of mental distress that incorporates a range of symptoms including depression and anxiety (Batty et al., 2022; Russ et al., 2012, 2015). GHQ scores are categorised as follows: asymptomatic (score 0), sub-clinically symptomatic/not substantially symptomatic (score 1–3), symptomatic (score 4–6), and highly symptomatic and indicative of substantial mental distress (score 7–12) (Russ et al., 2015). Those with scores of between 0 and 3 were considered to have good mental health for the purposes of restricting the sample at wave 1, 21,281 people met this condition and lived in a suitably warm home at wave 1 (Kearns et al., 2019). For our analysis exploring the impact of cold homes on people experiencing symptoms of mental distress, the sample is limited to those scoring between 4 and 6 on the GHQ-12 at wave 1, 2258 people met this condition and lived in a suitably warm home. Sample proportions are shown in Table 1.

Scores of between 7 and 12 are considered highly symptomatic and indicative of substantial mental distress (Batty et al., 2022; Russ et al., 2012, 2015). Our outcome variable is therefore a binary transformation of the GHQ-12 with 1 equalling a score of 7–12.

2.3. Predictor variable: cold homes

To measure whether people were living in cold homes, responses to the following question were used: "*In winter, are you able to keep this accommodation warm enough?*" A subjective indicator such as this, rather than a measure of temperature for example, is advantageous as it allows people to respond on the basis of their need (e.g., for warmer temperatures than average because of restricted movement or health conditions). It reflects their capacity and perception, as well as incorporating the combined effects of climate, housing design, financial resources, and need/preferences (Lelkes, 2013). The question specifically refers to indoor temperatures in the winter, so different timing of survey responses shouldn't affect results, nonetheless we include the month of survey in an additional model as a robustness check. A measure focusing on the ability to keep the home warm, rather than spending on energy, is more appropriate for the purposes of our research given the focus on the impacts of cold rather than energy/fuel poverty. This approach also avoids the challenges associated with fuel poverty indicators relating to imprecision and accounting for the varying operationalisations of fuel poverty within the UK (Kearns et al., 2019; Mould and Baker, 2017; Robinson et al., 2018). The question used for this analysis is asked in the household survey, and was asked at all waves except 3, 5, and 7. The nature of the survey collection means that data on home warmth is still available for all years of the survey.

2.4. Controls and confounders

We include several control and confounding variables in the analysis (Table 2, controls are time varying in the analysis but we report here the characteristics of respondents on entry to the survey). Models adjust for age and sex (binary male/female due to the data) given the associations with health and housing, including mental health (Vásquez-Vera et al., n.d.). Respondent ethnicity is included for similar reasons, as well as the differences in housing experiences of different ethnic groups (Finney and Harries, 2015; Gov.uk, 2020; ONS, 2020; Somerville and Steele, 2001). We also include an indicator of region in which the respondent lives, as climate, housing condition, the prevalence of different household heating types, and fuel costs vary across regions (Burlinson et al., 2021; Robinson et al., 2018). Employment status is included to control for other potential influences on health. A binary variable relating to the diagnosis of a longstanding illness or disability ("Do you have any long-standing physical or mental impairment, illness or disability? By 'long-standing' I mean anything that has troubled you over a period of at least 12 months or that is likely to trouble you over a period of at least 12 months") is included given the greater risk of mental health problems. We include an indicator of income quartile that is adjusted for inflation and equivalised according to household size and age, as in Clair and

Table 1
Mental distress and home temperature proportions in the full sample at wave 1, weighted, full sample.

	Can keep home warm	Cannot keep home warm	Total
Asymptomatic (score 0)	0.507	0.031	0.538
Sub-clinically symptomatic (score 1-3)	0.257	0.023	0.280
Symptomatic (score 4-6)	0.083	0.011	0.093
Substantial mental distress (score 7-12)	0.075	0.014	0.089
Total	0.922	0.078	1.000

Sample size 27,868,

Hughes (2019). We also include highest educational qualification. These measures relate to socio-economic position, which is related to housing situation and mental health (Evans et al., 2003). The presence of children aged 15 or under, multiple adults, and lone parents in the household are also accounted for using binary indicators due to the impact of household structure on finances, energy use, and potentially health (Kearns et al., 2019; Sangster et al., 2022). Given the association between cold housing and financial strain, we also adjust for a subjective measure of financial situation. We include a number of housing characteristics because of the importance of housing context to the research question. An indicator of housing tenure (owned outright, owned with mortgage, private rent, social rent, other) is included given the differences in housing conditions and control, including control over heating systems, as well as the different regulatory environments, associated with the different tenures of the UK. Building type has been linked with health (Clair and Hughes, 2019) and energy use (Kearns et al., 2019) previously and is therefore included, while an indicator of housing payment arrears is included to account for housing cost strain.

2.5. Methods

We apply multilevel discrete-time event (survival) models to our data, accounting for the censored nature of the data as well as survey design. Individuals are clustered within households, therefore experiencing the same household temperatures – indeed the outcome variable is collected at the household level. This, and other within-household similarities, mean that accounting for the household clustering in the analysis is essential. Clustering into primary sampling units is also accounted for. The nature of the UKHLS survey means that our data is interval censored, rather than continuous. As such we only know the interval (survey wave) in which the change in outcome (mental distress) occurred, not the exact date as would be the case in a continuous model. Time is therefore modelled as discrete. Models are created incrementally, first including only the ability to keep the home warm, then demographic variables, in the third model housing variables are added, and finally financial variables. Robustness checks using an alternative measure of mental health as well as including urban/rural location and month of survey were conducted. The analysis was conducted using Stata 17, all results are weighted to account for unequal selection probability.

3. Results

3.1. Who lives in cold homes (the harmed community)?

We first present results of bivariate analyses exploring differences in the likelihood of living a home that is too cold – the "harmed community". These results are weighted, adjusted for sample design, and based on the full sample of respondents with complete responses. Results show significant inequalities in who lives in a cold home, with certain groups at much higher risk than others.

Results in Fig. 1 show differences across demographics, all group differences are statistically significant at $p < 0.001$ unless otherwise stated. We find that, in keeping with previous research, women are more likely than men to live in cold homes (6.56% compared to 5.39%, $\chi2 = 22.39$). Households with single adults are more likely to live in cold homes (9.18% compared to 5.15%, $\chi2 = 124.52$), as were households containing lone parents (13.32% compared to 5.53%, $\chi2 = 186.76$). The difference between households depending on the presence of children (5.88% where there are no children, 6.22% where there are children) was not statistically significant. Those who reported a long-standing illness or impairment were significantly more likely to live in cold homes (7.80% compared to 4.94%, $\chi2 = 127.78$) and there were stark differences in the proportion of people living in cold homes across ethnic groups. Over 12% of Black respondents reported living in cold homes, more than double the percentage of White British respondents (5.61%, $\chi2 = 18.32$). The proportion living in cold homes also varied starkly by employment status, from 3.51% for those on maternity leave to 18.04% for unemployed respondents and 19.01% for those who are long-term sick. Interestingly, compared to the low reported levels of cold for those on maternity leave, 9.25% of those who reported family/home care as their employment status lived in cold homes ($\chi2 = 160.57$).

The proportion of respondents living in cold homes also varied across regions, from 4.61% in the East of England to 8.23% in Wales ($\chi2 = 2.68$, $p < 0.01$). There is significant variation across tenures ($\chi2 = 221.54$). Those living in homes owned outright had the lowest risk of reporting living in cold homes (2.91%) closely followed by those in homes owned with a mortgage (2.95%). Those in the social rented sector reported the highest risk (13.21%), with 10.82% of those in the private rented sector reporting living in cold homes (see Fig. 2). As well as tenure, there were differences across building type. For those in detached homes, 2.79% reported living in cold comes compared to 9.68% living in flats ($\chi2 = 65.97$). These findings are likely related, with the prevalence of building types varying across tenures. Housing arrears were associated with a much greater likelihood of living in a cold home – 17.81% compared to 4.99% ($\chi2 = 573.41$). Stark differences were also found with the financial variables: 1.31% of those living comfortably were living in cold homes compared to 32.01% of those who reported finding their financial situation 'very difficult' ($\chi2 = 963.85$). Similarly, 11.68% of those in the lowest age-standardised income quartile live in cold homes compared to 1.71% of those in the highest quartile ($\chi2 = 312.57$).

3.2. Cold homes and mental distress

Fig. 3 shows the results of the multilevel discrete-time event models predicting the odds of reporting severe mental distress (full results with all coefficients are shown in the appendices, Tables A1 and A2). The results show that becoming unable to keep the home adequately warm is associated with statistically significant increases in the odds of reporting severe mental distress for both those with no mental health problems on entry to the survey and those with borderline mental health problems. The odds ratio decreases with the introduction of controlling and confounding variables but remains significant, showing near double the odds of severe mental distress for those with good mental health at wave

Table 2
Descriptives for survey respondents at wave 1 (weighted proportions).

		Full sample	No/low mental health problems, home warm	Borderline mental health problems, home warm
	Able to keep the home suitably warm			
	Yes	0.92	1.00	1.00
	No	0.08	0.00	0.00
Demographics	Sex			
	Male	0.49	0.51	0.43
	Female	0.51	0.49	0.57
	Age (mean)	45.13	45.50	42.70
	Other/multiple adults present in household			
	No other adult	0.19	0.17	0.19
	Other adults present	0.81	0.83	0.81
	Children in household			
	No children	0.66	0.67	0.65
	Children present	0.34	0.33	0.35
	Single Parents in household			
	None	0.93	0.95	0.94
	Present	0.07	0.05	0.06
	Long-standing illness or impairment			
	No	0.64	0.69	0.58
	Yes	0.36	0.32	0.42
	Ethnic group			
	White British	0.85	0.88	0.83
	Other White	0.04	0.04	0.05
	Mixed background	0.01	0.01	0.02
	Asian	0.06	0.04	0.06
	Black	0.03	0.02	0.03
	Other	0.01	0.00	0.01
	Current labour force status			
	Employed	0.46	0.49	0.47
	Self-employed	0.07	0.07	0.05
	Unemployed	0.07	0.05	0.09
	Retired	0.21	0.22	0.17
	Maternity leave	0.01	0.01	0.01
	Family/home care	0.06	0.05	0.06
	Student	0.08	0.08	0.09
	Long-term sick	0.04	0.02	0.06
	Other	0.01	0.01	0.01
	Region			
	North East	0.04	0.04	0.04
	North West	0.11	0.12	0.12
	Yorkshire & Humber	0.08	0.08	0.07
	East Midlands	0.08	0.08	0.09
	West Midlands	0.08	0.08	0.08
	East of England	0.09	0.09	0.11
	London	0.12	0.11	0.12
	South East	0.13	0.14	0.14
	South West	0.09	0.10	0.09
	Wales	0.05	0.05	0.05
	Scotland	0.08	0.08	0.07
	Northern Ireland	0.03	0.03	0.03
Housing	Housing arrears (been 2+ months late with housing payment)			
	Inapplicable/no	0.91	0.93	0.89
	Yes	0.09	0.07	0.11
	Housing tenure			
	Owned outright	0.28	0.31	0.23
	Owned with mortgage	0.38	0.40	0.41
	SRS	0.20	0.16	0.20
	PRS	0.13	0.12	0.15
	Other	0.01	0.01	0.01
	Dwelling type			
	Detached	0.24	0.26	0.23
	Semi-detached	0.32	0.33	0.32
	Terrace	0.29	0.28	0.29
	Flat	0.14	0.12	0.16
	Other	0.01	0.01	0.01
Financial	Financial situation			
	Living comfortably	0.26	0.31	0.18
	Doing alright	0.33	0.35	0.29
	Just about getting by	0.28	0.26	0.32
	Finding it quite difficult	0.09	0.06	0.15
	Finding it very difficult	0.04	0.02	0.06
	Age-standardised income quartile			
	1	0.27	0.22	0.27
	2	0.26	0.26	0.26
	3	0.24	0.26	0.23
	4	0.23	0.26	0.24

Notes: Complete cases only, left column shows the groupings used to enter variables into the analytical models.

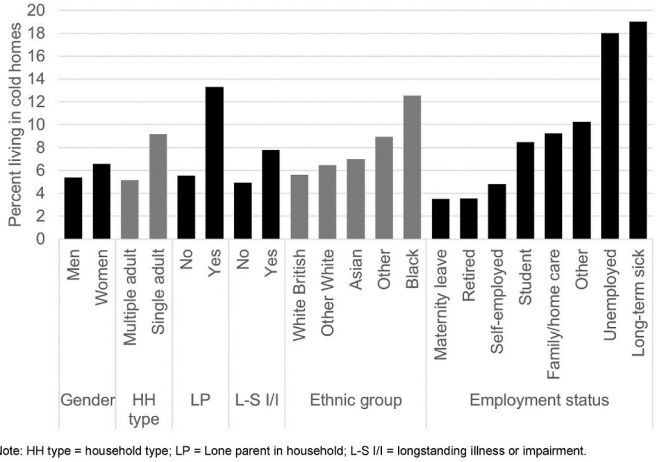


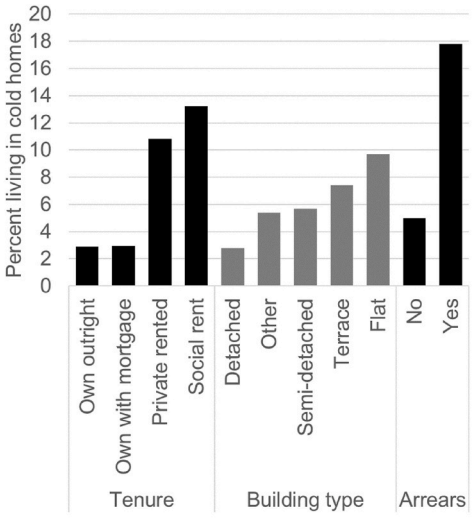
Fig. 1. Percent living in cold homes, demographics. Note: HH type = household type; LP = Lone parent in household; L-S I/I = longstanding illness or impairment.

1 and over triple odds of severe mental distress for those with borderline mental health at wave 1, relative to those who remained living in warm homes, even after including all control variables.

In addition to our models with main effects, we ran models to investigate whether the relationship between cold housing and mental distress is moderated by other factors. Gender, having a longstanding illness or disability, being in housing arrears, household structure and tenure were all considered as potential moderators. No significant interaction effects were found once the Bonferroni Correction for multiple tests was applied.

3.3. Robustness checks and limitations

We conducted robustness checks in order to test our findings (results available on request). We ran additional versions of the final models, for both those with no mental distress at wave 1 and those with borderline distress at wave 1, testing to see whether the addition of survey month or an indicator of whether the respondent lived in a rural or urban area would affect our findings. Neither of these variables were significant



Note: Arrears = housing payment arrears.

Fig. 2. Percent living in cold homes, housing variables. Note: Arrears = housing payment arrears.

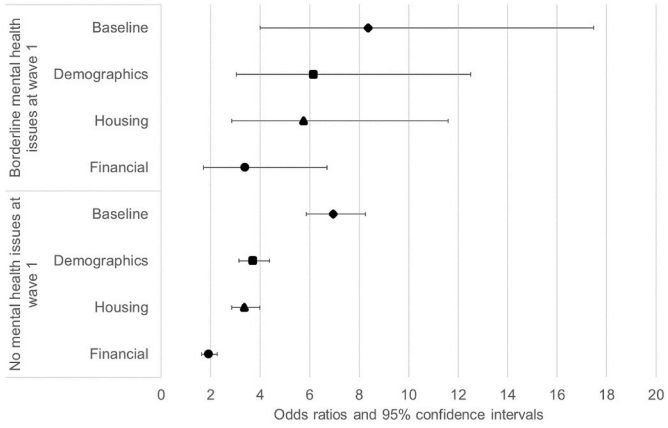


Fig. 3. Odds of reporting severe mental distress in models with different control variables included, sample living in warm homes at wave 1. Multilevel discrete time to event proportional odds models. All odds ratios statistically significant at p < 0.001 Variable groups were added cumulatively to the models, so the final versions of models include all demographic, housing and financial variables. Baseline refers to models with no controlling/confounding variables. Sample sizes: 115,309 for no mental health issues at wave 1 and 8399 for those with borderline mental health at wave 1.

when included, nor did they affect the other coefficients of interest.

Further, we tested our models using an alternative measure of mental health – the Short Form 12 Mental Health Component Summary – again limiting the sample based on mental health on entry to the survey – using cut off levels taken from Sanderson and Andrews (2002). Results were very similar to the models produced using the GHQ: for those with low/no mental health problems at wave 1 the coefficient for living in a cold home was 1.98 ($p = 0.002$). For those with borderline mental health problems at wave 1 the coefficient was reduced to 2.28 ($p = 0.002$) using this alternative outcome measure, but the result is substantively the same. The consistency of the sensitivity tests suggests that our findings are highly robust.

A few other potential limitations may affect our findings. It is possible that mental distress affects perceptions of temperature. We also note that different people may experience household temperature differently, which we are not able to account for using the current dataset. Further work may want to explore impacts based on moving into a new home which is cold, verses staying in a home that becomes cold.

4. Discussion and conclusions

Housing problems were estimated to cost the National Health Service (NHS) £2.5 billion in 2011, equivalent to the health costs of smoking (Nicol et al., 2015). Of the health hazards associated with housing, cold is among the most numerous, estimated to cost the NHS nearly £850 million per year. Our analysis documents the significant potential mental health harm of cold housing, especially for people already at risk of mental ill-health. While there is worthy concern (in both policy and research) for the well-documented physical health harms of living in cold housing – for example cardiovascular and respiratory diseases – mental health harm is less widely considered. The results of this analysis suggest that this is a significant oversight.

Supporting people to live in homes that are suitably warm will likely reduce public expenditure on health, as well as reducing suffering. While interventions are often discussed in terms of the cost to implement, our findings demonstrate the significant costs of inaction. Mental health problems account for 23% of NHS activity, indicating significant room for reducing spending (Mental Health Taskforce to the NHS in England, 2016). The true costs of inaction will of course include more than the costs associated with increased healthcare usage. The economic and social costs of mental health are estimated at £105 billion a year in England (Mental Health Taskforce to the NHS in England, 2016). But it is important to consider our findings in the context of an NHS struggling due to funding challenges and the effects of the COVID-19 pandemic, as well as the particular challenges facing those seeking treatment for mental health problems (NHS Providers, 2021).

We have conducted our research at a time of increasing inflation, living and energy costs in many countries. Recent work by the Joseph Rowntree foundation found that over one-quarter, or 3.2 million, low income UK households had been unable to adequately heat their home at some point in 2022 (Schmuecker and Earwaker, 2022). There has been an 8-fold increase in pre-payment energy users 'self-disconnecting' – stopping using energy – between April 2022 and April 2021 (Smith, 2022). Further, there is anecdotal evidence of people adapting to increased fuel prices by spending time on buses and in other public spaces (Dugan, 2022). Others are adapting by installing solid-fuel heating systems which are linked with health risks, or even starting open fires in their homes to keep warm (Pidd, 2022). These challenges follow the COVID-19 pandemic and associated lockdowns which exacerbated fuel poverty in the UK (Brown et al., 2022; Whitehead et al., 2022).

Yet the UK energy cap was recently frozen at £2,500, double the cap at the beginning of the year, although lower than cost predictions without intervention (e.g. Lowrey, 2022). This is in stark contrast to government efforts to control energy prices elsewhere, notably France (Giles et al., 2022). This failure to strongly intervene compounds extensive evidence of severe financial hardship and two decades of increasing poverty in the UK (JRF, 2022). There was a 57% jump in households skipping meals/cutting down on food between January and April 2022 – affecting 7.3 million adults and 2.6 million children (The Food Foundation, n.d.). The use of food banks continues to rise, but the already limited options available to food bank users are being further restricted by the energy costs – with food bank users increasingly unable to accept food that requires cooking (Sweney, 2022). There are also reports that households are pawning belongings to meet everyday food costs (Social Market Foundation, 2022). People are therefore suffering significant financial (Hillyard and Tombs, 2007) and mental health (Reeves et al., 2016) harms through ideologically driven social security cuts and high prices for essentials, particularly fuel, while fuel companies make significant profits (Espiner, n.d.; Meierhans, 2022).

While our analysis focuses on the UK, it is likely that similar

relationships between cold homes and mental health harm are found internationally. We note that in many countries, including the UK which recently recorded its highest ever temperature, climate change means that there is justifiable concern about mortality and morbidity due to excess heat. This is of course a significant concern, but evidence shows that cold remains responsible for more temperature related deaths in the UK, Australia and other countries than heat (Gasparrini et al., 2015).

The health risk from people living in cold homes is avoidable. We have shown that these living conditions are associated with an increased risk of experiencing mental health harm. Supporting people to live in suitably warm homes is an obvious and effective target for intervention. Our results reinforce the usefulness of the social harm conceptualisation to frame research on the effects of cold housing, as well as housing problems more generally. The social harm conceptalisation reminds us that the harm (health effect) should not be simply attributed to the house being cold. It forces us to acknowledge that the health effect of cold housing, is the result of climate, existing illness, dwelling suitability, heating affordability and accessibility, income, age, tenure, etc. all working together.

There are a number of steps that the government could take to ease the challenges people are facing, recognising the unequal risk of being part of the harmed community. Financial support for people with low incomes could be improved, both in terms of increasing social security support and removing policies which penalise those on low incomes, such as the in-built waiting period before Universal Credit, the main social security benefit, payments kick in (Schmuecker and Eawaker, 2022). Similarly, the benefit cap could be removed or significantly increased. The government could overcome their commitment to deregulation and intervene more actively in the energy sector, as seen in other countries including France and Australia, as well as in the housing market enforcing higher standards of energy efficiency and build quality. They could tackle the challenge of the 'split incentive' (Bird and Hernández, 2012) which leaves renters unable to benefit from incentives to improve energy efficiency. Until such steps are taken, we must conclude that cold homes are source of avoidable social harm.

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Credit author Statement

Amy Clair: Conceptualisation; Data curation; Formal analysis; Investigation; Methodology; Writing – original draft; Writing – review & editing. **Emma Baker**: Conceptualisation; Funding acquisition; Writing – original draft; Writing – review & editing.

Declarations of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

Appendices.

Table A1
Predicting severe mental distress from a sample living in warm homes and with no symptomatic levels of mental distress at wave 1. Multilevel discrete time to event proportional odds models

		Warm only	Demog-raphics	Housing	Financial
		OR (SE)	OR (SE)	OR (SE)	OR (SE)
Able to keep accommodation warm (no)		6.95***	3.71***	3.37***	1.92***
		(0.61)	(0.31)	(0.29)	(0.16)
Age at Date of Interview			0.98***	0.99***	0.99***
			(0.00)	(0.00)	(0.00)
Sex (female)			1.76***	1.76***	1.82***
			(0.09)	(0.09)	(0.10)
Other adult(s) in home (yes)			0.86*	0.93	0.93
			(0.05)	(0.06)	(0.06)
Child(ren) present in home			1.00	0.94	0.90
			(0.07)	(0.06)	(0.06)
Single parent(s) in home (yes)			1.41**	1.41**	1.40**
			(0.16)	(0.16)	(0.14)
Longstanding illness or impairment (yes)			3.86***	3.86***	3.76***
			(0.20)	(0.19)	(0.17)
Ethnicity (ref. White British)	Other White		1.04	1.02	1.01
			(0.15)	(0.14)	(0.14)
	Mixed background		1.03	0.99	0.88
			(0.20)	(0.20)	(0.17)
	Asian		1.10	1.11	0.92
			(0.11)	(0.12)	(0.10)
	Black		0.79	0.72*	0.53***
			(0.13)	(0.12)	(0.08)
	Other background		1.14	1.09	0.92
			(0.38)	(0.36)	(0.30)
Employment status (ref. Employed)	Self-employed		0.87	0.89	0.82*
			(0.08)	(0.08)	(0.08)
	Unemployed		3.43***	3.27***	2.14***
			(0.33)	(0.32)	(0.21)
	Retired		0.76**	0.84	0.99
			(0.07)	(0.08)	(0.09)
	Maternity leave		1.10	1.10	1.11
			(0.26)	(0.26)	(0.26)

(*continued on next page*)

Table A1 (*continued*)

		Warm only	Demog-raphics	Housing	Financial
		OR (SE)	OR (SE)	OR (SE)	OR (SE)
	Family/home care		1.53***	1.50***	1.31*
			(0.16)	(0.16)	(0.14)
	Student		0.63**	0.65*	0.67*
			(0.11)	(0.11)	(0.11)
	Long-term sick		7.79***	7.25***	5.68***
			(0.83)	(0.78)	(0.61)
	Other		1.33	1.35	1.05
			(0.32)	(0.32)	(0.26)
Region (ref. North East)	North West		0.91	0.93	0.88
			(0.12)	(0.13)	(0.12)
	Yorkshire & Humber		0.94	0.96	0.92
			(0.14)	(0.14)	(0.13)
	East Midlands		0.82	0.86	0.77
			(0.12)	(0.13)	(0.11)
	West Midlands		1.29	1.34*	1.24
			(0.19)	(0.19)	(0.18)
	East of England		pr	0.92	0.84
			(0.13)	(0.13)	(0.12)
	London		0.95	0.93	0.85
			(0.14)	(0.14)	(0.12)
	South East		0.97	1.00	0.91
			(0.13)	(0.14)	(0.12)
	South West		0.97	1.00	0.89
			(0.14)	(0.14)	(0.12)
	Wales		0.90	0.93	0.82
			(0.15)	(0.15)	(0.13)
	Scotland		0.86	0.87	0.80
			(0.13)	(0.13)	(0.12)
	Northern Ireland		0.71*	0.72	0.68*
			(0.12)	(0.12)	(0.12)
Housing arrears (yes)				1.46***	1.01
				(0.11)	(0.07)
Tenure (ref. owned outright)	Owned with mortgage			1.45***	1.16*
				(0.10)	(0.08)
	Social Rent			1.60***	1.13
				(0.13)	(0.10)
	Private Rent			1.59***	1.13
				(0.15)	(0.11)
	Other			1.26	1.05
				(0.30)	(0.26)
Building type (ref. detached)	Semi-detached			1.07	0.98
				(0.07)	(0.06)
	Terrace			1.08	0.95
				(0.08)	(0.07)
	Flat			1.06	0.98
				(0.10)	(0.10)
	Other			1.28	1.27
				(0.29)	(0.29)
Subjective financial situation (ref. living comfortably)	Doing alright				1.56***
					(0.09)
	Just about getting by				3.66***
					(0.26)
	Finding it quite difficult				10.42***
					(0.95)
	Finding it very difficult				22.24***
					(2.77)
Income quartile, age equivalised (ref. first quartile)	2nd quartile				1.14*
					(0.06)
	3rd quartile				1.27***
					(0.08)
	4th quartile				1.37***
					(0.10)
Hazard function		2.11***	2.22***	2.22***	2.46***
		(0.05)	(0.06)	(0.07)	(0.08)
Random effects					
Variance: PSU		1.20	0.87	0.87	0.78
		(0.08)	(0.06)	(0.06)	(0.06)
Variance: HID		4.17	4.07	4.06	3.93
		(0.25)	(0.24)	(0.24)	(0.23)
Constant		0.00***	0.00***	0.00***	0.00***
		(0.00)	(0.00)	(0.00)	(0.00)
Observations		115,309	115,309	115,309	115,309
Number of groups		4957	4957	4957	4957

***p < 0.001, **p < 0.01, *p < 0.05.

Table A2
Predicting severe mental distress from a sample living in warm homes and with borderline severe levels of mental distress at wave 1. Multilevel discrete time to event proportional odds models

		Warm only	Demog-raphics	Housing	Financial
		OR (SE)	OR (SE)	OR (SE)	OR (SE)
Able to keep accommodation warm (no)		8.36***	6.16***	5.76***	3.38***
		(3.14)	(2.22)	(2.06)	(1.18)
Age at Date of Interview			0.98*	0.98	0.98
			(0.01)	(0.01)	(0.01)
Sex (female)			1.40	1.39	1.45
			(0.27)	(0.27)	(0.28)
Other adult(s) in home (yes)			0.79	0.90	0.86
			(0.17)	(0.21)	(0.19)
Child(ren) present in home			1.17	1.11	1.02
			(0.26)	(0.25)	(0.23)
Single parent(s) in home (yes)			1.48	1.51	1.32
			(0.55)	(0.56)	(0.50)
Longstanding illness or impairment (yes)			4.36***	4.26***	3.60***
			(0.97)	(0.94)	(0.74)
Ethnicity (ref. White British)	Other White		0.38	0.37	0.40
			(0.22)	(0.21)	(0.22)
	Mixed background		1.45	1.40	1.18
			(1.01)	(0.97)	(0.78)
	Asian		1.08	1.12	0.97
			(0.40)	(0.41)	(0.37)
	Black		0.66	0.61	0.43
			(0.40)	(0.38)	(0.26)
	Other background		0.81	0.75	0.60
			(0.72)	(0.66)	(0.57)
Employment status (ref. Employed)	Self-employed		0.98	1.01	0.83
			(0.31)	(0.32)	(0.26)
	Unemployed		3.62***	3.62***	2.21*
			(1.33)	(1.33)	(0.79)
	Retired		1.18	1.32	1.66
			(0.36)	(0.40)	(0.51)
	Maternity leave		0.58	0.57	0.53
			(0.45)	(0.44)	(0.41)
	Family/home care		1.06	1.06	1.06
			(0.39)	(0.40)	(0.40)
	Student		0.21*	0.21*	0.23*
			(0.13)	(0.13)	(0.15)
	Long-term sick		6.71***	6.40***	5.44***
			(2.47)	(2.36)	(2.00)
	Other		3.31	3.29	2.26
			(2.87)	(2.84)	(1.95)
Region (ref. North East)	North West		0.99	1.06	0.94
			(0.47)	(0.51)	(0.44)
	Yorkshire & Humber		1.72	1.97	1.61
			(0.85)	(0.98)	(0.79)
	East Midlands		1.07	1.16	0.97
			(0.53)	(0.58)	(0.49)
	West Midlands		1.44	1.56	1.26
			(0.70)	(0.76)	(0.62)
	East of England		1.79	1.82	1.60
			(0.85)	(0.87)	(0.75)
	London		1.75	1.69	1.47
			(0.91)	(0.89)	(0.76)
	South East		1.47	1.53	1.32
			(0.69)	(0.73)	(0.62)
	South West		1.40	1.44	1.09
			(0.70)	(0.73)	(0.53)
	Wales		1.48	1.59	1.40
			(0.87)	(0.94)	(0.83)
	Scotland		1.36	1.38	1.22
			(0.72)	(0.73)	(0.65)
	Northern Ireland		0.95	1.00	0.87
			(0.64)	(0.68)	(0.58)
Housing arrears (yes)				0.93	0.62
				(0.25)	(0.18)
Tenure (ref. owned outright)	Owned with mortgage			1.66*	1.42
				(0.41)	(0.35)
	Social Rented Sector			1.82	1.21
				(0.56)	(0.37)
	Private Rented Sector			2.29*	1.62
				(0.80)	(0.56)
	Other			1.41	1.05
				(1.50)	(1.11)

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Table A2 (*continued*)

		Warm only	Demog-raphics	Housing	Financial
		OR (SE)	OR (SE)	OR (SE)	OR (SE)
Building type (ref. detached)	Semi-detached			0.77	0.67
				(0.19)	(0.16)
	Terrace			0.89	0.76
				(0.23)	(0.20)
	Flat			0.99	0.89
				(0.37)	(0.33)
	Other			2.34	2.21
				(1.66)	(1.58)
Subjective financial situation (ref. living comfortably)	Doing alright				1.67*
					(0.36)
	Just about getting by				4.65***
					(1.21)
	Finding it quite difficult				11.99***
					(4.21)
	Finding it very difficult				31.38***
					(15.89)
Income quartile, age equivalised (ref. first quartile)	2nd quartile				1.25
					(0.26)
	3rd quartile				1.16
					(0.28)
	4th quartile				1.34
					(0.34)
Hazard function		3.18***	3.38***	3.39***	4.02***
		(0.38)	(0.47)	(0.47)	(0.62)
Random effects					
Variance: PSU		3.90	3.10	3.08	2.87
		(0.72)	(0.60)	(0.60)	(0.57)
Variance: HID		8.07	8.47	8.26	8.23
		(2.28)	(2.57)	(2.48)	(2.43)
Constant		0.00***	0.00***	0.00***	0.00***
		(0.00)	(0.00)	(0.00)	(0.00)
Observations		8399	8399	8399	8399
Number of groups		1260	1260	1260	1260

***p < 0.001, **p < 0.01, *p < 0.05.

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