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The impact of persistent poor housing conditions on mental health: a longitudinal population-based study

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ABSTRACT (max 250)

Living with housing problems increases the risk of mental ill health. Housing problems tend to persist over time but little is known about the mental health consequences of living with persistent housing problems. We determine if persistent poor housing affects mental health over and above the effect of current housing conditions. We use data from 13 annual waves of the British Household Panel Survey (1996 to 2008) (person/years = 81,745 from 16,234 individuals) and measure the persistence of housing problems by the number of years of the past four that a household experienced housing problems. OLS regression models and lagged-change regression models are used to estimate the effects of past and current housing conditions on mental health, as measured by the General Health Questionnaire. Interaction terms test if tenure type modifies the mental health effects of persistent poor housing. In fully adjusted models, mental health worsens as the persistence of housing problems increases. Adjustment for current housing conditions attenuated, but did not explain, the findings. Tenure type moderates the mental health effects of persistent poor housing, suggesting those who own their homes outright and who live in social housing are most negatively affected. Persistence of poor housing is predictive of worse mental health, irrespective of current housing condition, adding to the weight of evidence that living in poor quality housing for extended periods of time has negative consequences for mental health.

1. **INTRODUCTION**

It is generally accepted that good housing protects health (Shaw, 2004; Thomson and Thomas, 2015). Exposure to poor housing conditions, such as damp, leaks, and inadequate heating, has been demonstrated to increase the risk of developing respiratory infections and asthma, but also more serious conditions such as tuberculosis (Bonnefoy et al., 2003; Shaw, 2004; Walker et al., 2006; Bonnefoy, 2007; Webb et al., 2013). Poor housing conditions also affect mental health. People living in housing with more problems have a greater likelihood of experiencing mental ill health (Pevalin et al., 2008) while physical improvements to housing improves mental health (Curl et al., 2015; Willand et al., 2015). However, the influence of longer-term exposure (persistence) to poor housing on mental health specifically remains unclear (Marsh et al., 2000). This paper aims to address two questions: does the persistence of poor housing conditions over the previous 4 years affect mental health in the present, and does a person's experience of poor housing conditions in the past continue to affect their mental health in the present irrespective of whether they are currently experiencing housing problems?

People who are living in poor housing conditions today are far more likely to experience poor housing conditions in the future. Data from the UK shows that among people living with (one or more) housing problems in 2001, 57% had housing problems in 2002, and 56% had housing problems in 2003. Some housing problems may change year to year but others, such as damp, may be especially difficult to rectify. Among people who report housing conditions (2000 to 2003), around 9% report one or more housing problems in every year.

Persistence of poor housing may in part be due to a lack of autonomy or inadequate financial resources (Kemp, 2011; Desmond, 2016). Renters are reliant on their landlords to fix housing problems. In the low cost end of the housing market landlords have few incentives to make costly repairs and so renters may be forced to choose between poor quality housing and trying to find better quality housing, which may require moving and be less affordable (Kemp, 2011). Similarly, and especially among lower-income homeowners, housing problems may persist because households lack the financial resources to engage tradespeople (Bogdon, 1996).

We argue that – similar to unemployment – the health consequences of housing problems at a particular point-in-time may be quite different from health effects of housing problems that persist over time (Paul & Moser, 2009). The association between current housing problems and current mental health may overlook the persistence of housing problems and the toll they take on mental health. Further complicating the interpretation of any association between housing problems and health are potential effect lags. Mental health problems may be 'sticky'; persisting even after the initial trigger has been removed (Clark et al., 2001; Lucas et al., 2004; Davydov et al., 2010; Huijts et al., 2015). Previous housing problems may initiate stress and anxiety that is not immediately alleviated when the problem is fixed (Curl et al., 2015).

Building on the previous literature, we hypothesize that housing problems in the past will affect health in the present and that this relationship will be observable even after accounting for current housing problems. To explore this hypothesis, we develop a new measure of housing problems over time using a longitudinal data set that is better able to disentangle the health effects of current and past housing problems. To our knowledge, few studies have attempted to disentangle the health consequences of current and previous housing conditions. Our study, therefore, provides one of the first examinations of the cumulative impact of housing problems on mental health.

2. METHODS

2.1. Study Sample

The data came from the 13 annual waves (1996 to 2008) of the British Household Panel Survey (BHPS) that included questions about housing conditions. A well-established survey, the BHPS is extensively documented (Taylor et al., 2010; University of Essex, 2010). Panel data for analysis was unbalanced as individuals move in and out of the survey according to a set of following rules (Taylor et al., 2010). To be included in the sample for this analysis an individual had to not have any missing values on all of the six measures of housing quality, described below (excluding 269 respondents; 2347 person/years). The main analytical sample contained N = 16,234 individuals (81,745 person/year observations). In the longitudinal analysis, respondents were required to have complete data for the current year and three years prior (excluding 7869

respondents; 46,660 person/years). Descriptive statistics for the analytical sample are provided in Table 1.

[Table 1 near here]

2.2. Measures

Households are asked "Does your accommodation have any of the following problems?" and are then shown a list including the six items directly related to poor housing conditions: not enough light; lack of adequate heating; condensation; leaky roof; damp walls or roof etc.; and rot in the walls or floor etc. If a respondent answered 'yes' to any of these six indicators they were considered as living with a housing problem in that year, which is consistent with other studies in the field (Webb et al., 2015). When housing problems emerge they tend to be linked with condensation (~26%), rot (~23%), or damp (~20%). We measured the density of housing problems as the proportion of years over the last four years that people have been living with housing problems. For example, in 2000:

Housing problem density$_{2000}$ = (Housing problem$_{2000}$ + Housing problem$_{1999}$ + Housing problem$_{1998}$ + Housing problem$_{1997}$)/4

One possible problem with this measure is that it assumes that the mental health effects of housing problems in the distant past are the same as the mental health effects in the recent past. But this may be incorrect, the past may matter more than the present or the present may matter more than the past. We explore these how these possibilities may affect our results using a simulation that uses weights to stress the importance of the past or the present, creating 1000 different versions of the density of housing problems. Each one is then used in a different regression model to see how much the association between persistent poor housing and mental health varies depending on the assumptions made regarding how the past affects the future (Full details of procedure in Table S1).

Our analyses also controlled for: age (in years) and sex (0=male, 1=female); a self-reported measure of current financial strain (1 is 'living comfortably' and 5 is 'finding it very difficult');

moved in the last 12 months; equalized monthly income before housing costs using the McClements Equivalence Scales (McClements, 1977; Taylor et al., 2010); marital status (0=married or cohabiting, 1=divorced, separated, widowed, 2=never married), and tenure type (0=mortgage, 1=rent in private sector, 2=rent social housing, 3=own outright). The prevalence of housing problems and mental ill health vary across by geography, we therefore include a series of regional indicators for each UK government office region. As a final set of controls we included time dummies to adjust for spatial correlation over time.

Mental health was measured by the 12-item General Health Questionnaire (GHQ). The GHQ is a widely used measure of mental health. Usually self-administered, it is based on the respondent's assessment of their present state relative to their usual or normal state. It is used here as an indicator of minor psychiatric morbidity and has been assessed to be a useful longitudinal indicator of mental health (Goldberg and Williams, 1988; Pevalin, 2000). The GHQ items were scored 0-3 resulting (after some items being reversed coded) in an overall score of 0-36 with a higher score indicating poorer mental health. Internal consistency of the GHQ in waves of data included in this study were alpha=0.89 to 0.91. We exclude individuals who have missing data on any of these covariates (41 respondents).

2.3. Statistical analysis

Our analyses consist of three main types of models. First, using pooled OLS regression we estimated the association between the density of housing problems over the last four years and mental health. This tests whether people exposed to more housing problems over the recent past have poorer mental health than those exposed to fewer housing problems.

1) $\text{Health}_{it} = \alpha_i + \beta_1 \text{Density}_{it} + \beta\chi_{it} + \eta_{it} + \nu_t + \varepsilon_{it}$

Where *Health* is the measure of GHQ, *Density* is our measure of the density of housing problems over the last 4 years, $\beta\chi$ is a vector of individual level control variables (e.g., age, sex, etc.), α is the constant, η is the region dummies, ν is the time dummies, and ε is the error term.

Second, we use pooled OLS regression models to estimate whether the density of housing problems predicts mental health over and above the effect of current housing problems.

2) $Health_{it} = \alpha_i + \beta_1 Problem_{it} + \beta_1 Density_{it-1} + \beta\chi_{it} + \eta_{it} + \nu_t + \varepsilon_{it}$

We estimate the same model as equation 1 except for two differences: first we now use the lagged measure of the density of housing problems (e.g., the density of housing problems from 1999 to 2002) and second we add the covariate *Problem*, which is a measure of the presence of housing problems (e.g., in 2003). We also estimate an additional model which includes an interaction term between lagged persistent housing problems and tenure type.

Finally, we estimate a lagged-difference model to examine the association between long-term (4 years) changes in housing problems and long-term (4 years) changes in mental health. In a subsequent step we add a measure of change in housing problems over the last year to test whether the long-term change in mental health is driven by long- or short-term changes in housing problems.

3) $\Delta Health_{i,t - t-3} = \alpha_i + \beta_1 \Delta Problem_{i,t - t-1} + \beta_1 \Delta Density_{i,t - t-3} + \beta\chi_{it} + \beta\chi_{it-3} + \eta_{it} + \nu_t + \varepsilon_{it}$

Here *ΔHealth* and *ΔDensity* are both measured as 4-year change variables. For example, GHQ score in 2004 minus GHQ score in 2001. Our vector of control variables $\beta\chi_{it}$ now includes measures of these covariates at t-3 ($\beta\chi_{it-3}$). One advantage of this analysis is that it removes any bias in our estimates due to time invariant confounders, such as genetics, and we exclude people who move house from the analysis to be more confident we are only capturing the consequences of changes in housing problems. In all analyses standard errors were adjusted for clustering at the individual level.

Statistical modelling and analysis were conducted in 2016 Stata 14 software. The University of Essex Ethics Committee approved this research using existing anonymised survey data.

3. RESULTS

Initially we examine whether one year of housing problems is associated with poorer mental health. We follow the same individuals over a five-year period and compare the association between experiencing housing problems in only one of those years and experiencing no housing problems over this same period. We plot coefficients in Figure S1. In all cases the association is positive suggesting that experiencing housing problems – even for only one year – affects mental health in the present. However, the association between housing problems and mental health diminishes over time. Surprisingly, it is only when we look back at housing problems four years ago that we see the confidence intervals marginally cross zero ($p = 0.052$) suggesting the impact of housing problems on mental health may be long-term - as long as five years.

Having documented the long-term association between housing problems and mental health we now explore the association between persistent poor housing and mental health (Table 2). We find that as the density of housing problems increases over a four-year period, people report higher average GHQ scores (indicating poorer mental health). In fully adjusted models, average GHQ scores increase by 0.92 [95%CI 0.72-1.13] as the density of persistent of housing problems increases.

[Table 2]

After we adjust for the current experience of housing problems in the fully adjusted model (Table 3: Model 3) the association between persistent poor housing and mental health attenuates but remains statistically significant ($\beta = 0.65$ 95% CI 0.45-0.84). In short, people who do not have housing problems now but who have experienced housing problems in the past, have poorer mental health than someone who has not experienced any housing problems over the last 5 years.

[Table 3]

Next we test whether there is an interaction between tenure type and lagged persistent housing problems (Figure 1). This interaction term reveals differences in slope by tenure type. Persistent housing problems are associated with form of tenure although the association is weaker among

those who have a mortgage. In contrast, persistent housing problems appear to harm mental health most among outright owners and renters in the social sector.

[Figure 1]

One reason the mental health effects of housing problems may vary across tenure is housing autonomy, or the ability to move or solve problems. Private renters and mortgage holders move more regularly than owner occupiers and have more autonomy to solve problems than social renters. We, therefore, explore the mental health effects of residential moves if they coincide with fewer housing problems and whether these effects are different from housing improvements for non-movers. Looking only people who have experienced housing problems in the previous year, we observe what happens to their health depending on whether (i) their housing problems end and/or (ii) they moved property (Figure 2). Getting rid of housing problems improves health regardless of whether someone moves out of their prior, poor quality home or if the problem ends (possibly linked to housing improvement). People who experience persistent housing problems have poor health, but those who move from one poor quality home to another experience an additional penalty.

[Figure 2]

Finally, we consider the long-term relationship, examining change in both housing problems and mental health over the last four years (Table 4: Model 1), finding evidence that worsening housing conditions is associated with worsening mental health ($\beta = 0.17$, 95%CI 0.06-0.28). Crucially, this analysis is restricted to only those who do not move house across this period, therefore capturing declining housing conditions within the same property. This relationship holds even if we control for any recent changes in housing problems and all other confounders ($\beta = 0.17$, 95%CI 0.04-0.29) (Table 4: Model 2).

[Table 4]

3.1. Sensitivity tests

First we tested whether our results are contingent on our assumption that each year of poor housing affects mental health in the same way. We use a simulation procedure to weight housing problems in the past and present and then see how much this influenced our results, finding that our results are not changed when we stress the importance of present or past housing problems (Table S1). We also tested a cumulative measure of housing problems (Table S2), that counted the number of problems not just the presence of any problem, finding similar results to the measure reported in Table 4. Next we explored whether using a narrower (3 year) or wider (5 year) time window alters our results, finding that they do not (Table S3). We also adjust for a lagged measure of GHQ (measured 4 years earlier) to test if poor mental health increases the likelihood of persistent housing problems, but even this control does not alter our findings (Table S4). Our analytic sample has a larger proportion of women than the general sample and this may bias our results; but we find no clear gender differences in the coefficients if we stratify our models by gender (Figure S2). We also estimate multilevel models where the level-1 clusters are either individuals or households, finding our results, again, do not change (Table S5).

4. DISCUSSION

Three main conclusions can be drawn. First, living with housing problems in the past is associated with poorer mental health in the present. Second, living in persistently poor housing negatively harms mental health over and above the effect of current housing problems. Mental health effects of persistent housing problems vary by tenure type, harming social renters and owner-occupiers most. Third, among people who remained in the same residence, but developed new housing problems, there was an association with poorer mental health. Taken together, these findings suggest a strong, long-term impact of persistent poor housing on mental health.

Our study has important limitations. First, housing problems appear closely associated with lack of choice in the housing market and limited financial resources, both of which may independently affect mental health (Bentley et al., 2011; Reeves et al., 2016b), and our analysis cannot capture landlord specific differences that may affect the ability of tenants to have problems fixed quickly by responsive landlords. Second, self-reporting housing problems may involve some measurement error due to subjective differences in how people describe problems

(e.g. condensation). However, such differences are largely stable over time and such measurement error will likely bias our estimates downward toward zero. Moreover, lagged difference models account for differences between individuals that are constant over time and so changes in self-reported housing problems likely reflect meaningful differences to respondents. Third, reverse causality may partially influence our results. For example, a history of poor mental health, particularly a serious psychotic episode in youth, may lead to lower incomes and restricted housing choices. Although we find that measuring mental health 5 years earlier does explain our primary findings, we acknowledge that episodes of mental distress may have a long-term scarring effect on access to quality housing. Fourth, our regional indicators represent broad areas, such as inner London, and likely reflect a wide range of housing conditions. Future research could use more fine-grained local areas to test the influence of living in areas of poor quality housing.

This study also suggests avenues for future research. First, the emergence of housing problems within households may not be random with respect to the household members and so future research may benefit from utilizing natural experiments or instrumental variables to identify exogenous sources of change in housing problems that are independent of household characteristics (Morgan and Winship, 2007). Second, while persistent poor housing seems to have long-term impact on mental health there is still variation across individuals in how housing problems affect health. More work is needed to understand whether neighborhoods, service accessibility, or family ties moderate the impact of housing problems on health (Clair et al, forthcoming).

Our results also have important implications for policy. Transitioning into housing problems has long-term consequences for health and so policies that stop problems arising may protect health and reduce public spending (due to reductions in healthcare and sick days due to common mental illness). At the extreme end, 'slum landlords' exist because there is a pool of possible tenants who have limited alternative housing choices (Desmond, 2016). Such tenants may have poor credit ratings or low incomes and so intervening in these markets may require basic income programs that ensure people can afford good quality housing. Alternatively, some tenants may have limited housing choices because of health or behavioral conditions that leave them unable

to maintain a traditional tenancy. For such tenants, affordability interventions may be insufficient to address housing quality problems. The vast majority of renters in this study, however, do not have persistent problems with their housing. For the most part, they are living in rented accommodation with landlords (private and state) of varying degrees of responsiveness. Policies that require landlords to undertake inspections of housing quality and limit their ability to initiate new tenancies, or increase rents if such inspections are not carried out, may incentivize landlords. One possible reading of our results is that there is little point in improving quality once housing problems have emerged. Here we argue that lifting people out of housing problems gradually improves mental health so that within a few years previously exposed people return to levels of mental health that are comparable with their peers.

Our findings also suggest that mental health policy needs to more explicitly recognize the housing conditions of those who engage directly with mental health services. As Marmot has argued, 'why treat people only to send them back to the conditions that made them sick' (2015: 1). In 2012, the UK government committed to regarding mental and physical health with parity of esteem, and promised additional funds to mental health services (Millard and Wessley, 2014). But these commitments emerged at the same time as government spending on housing-related areas was reduced, including local authority budgets (which partially fund refitting poor quality housing) and reductions in financial support for those in private rental sector (Reeves et al., 2016a). While the additional support for mental ill health is laudable, any benefits may well be offset by declining housing quality and greater financial stress created by cuts elsewhere.

Poor housing quality can have a long-term, scarring effect on mental health. Although housing quality appeared to be improving somewhat in the UK before the Global Financial Crisis, around one fifth of the population were still living with one or more housing problems in 2008. The Global Financial Crisis has likely made things worse and austerity policies, which are still being rolled out, have place additional pressure on household budgets (Lupton et al., 2016; Reeves et al., 2016a). Under these conditions, housing problems may begin to rise, having long-term consequences for mental health.

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Figures:

Figure 1: The association between persistent housing problems and mental health varies by tenure type. Data from British Household Panel Survey (1996-2008).

Figure 2: Interaction between contemporary housing problems, previous housing problems, and moving.

Figure 1: The association between persistent housing problems and mental health varies by tenure type. Data from British Household Panel Survey (1996-2008).
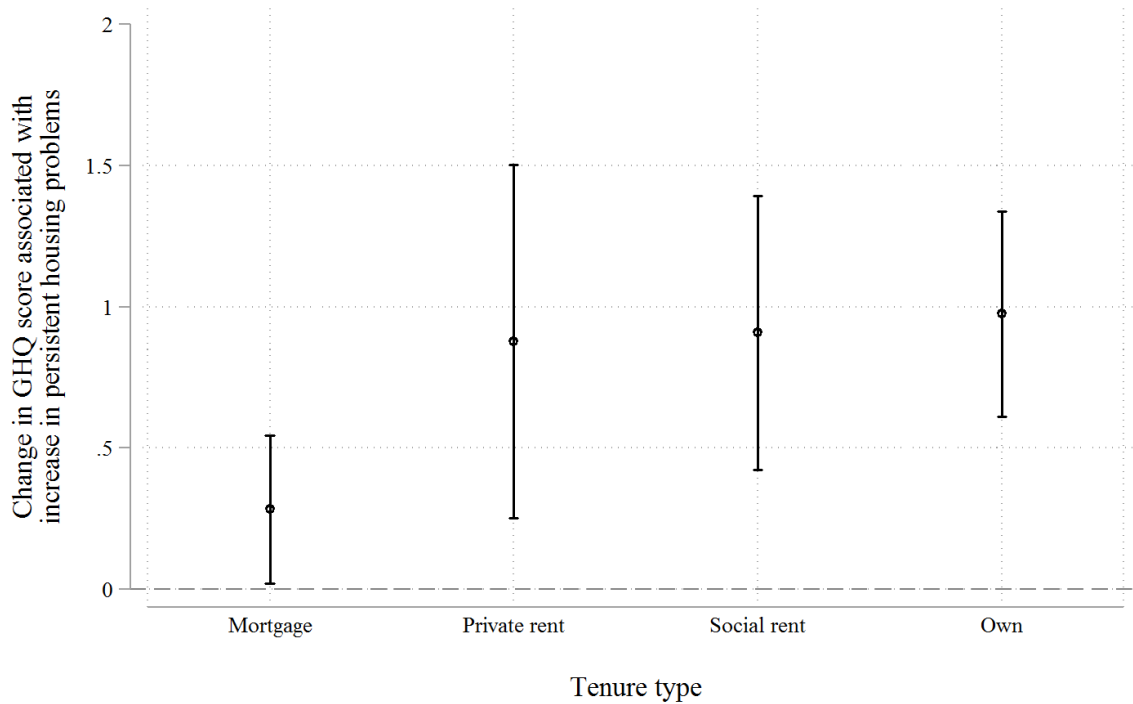
Notes: Results are based on table 2, model 3; but this model includes an interaction term between previous tenure type now and persistent housing problems in the past. Difference in coefficients between mortgage and private rent = 0.60, 95% CI: -0.079 to 1.27; between mortgage and social rent = 0.63, 95% CI: 0.073 to 1.18; between mortgage and owners = 0.69, 95% CI: 0.25 to 1.13.

Figure 2: Interaction between contemporary housing problems, previous housing problems, and moving.
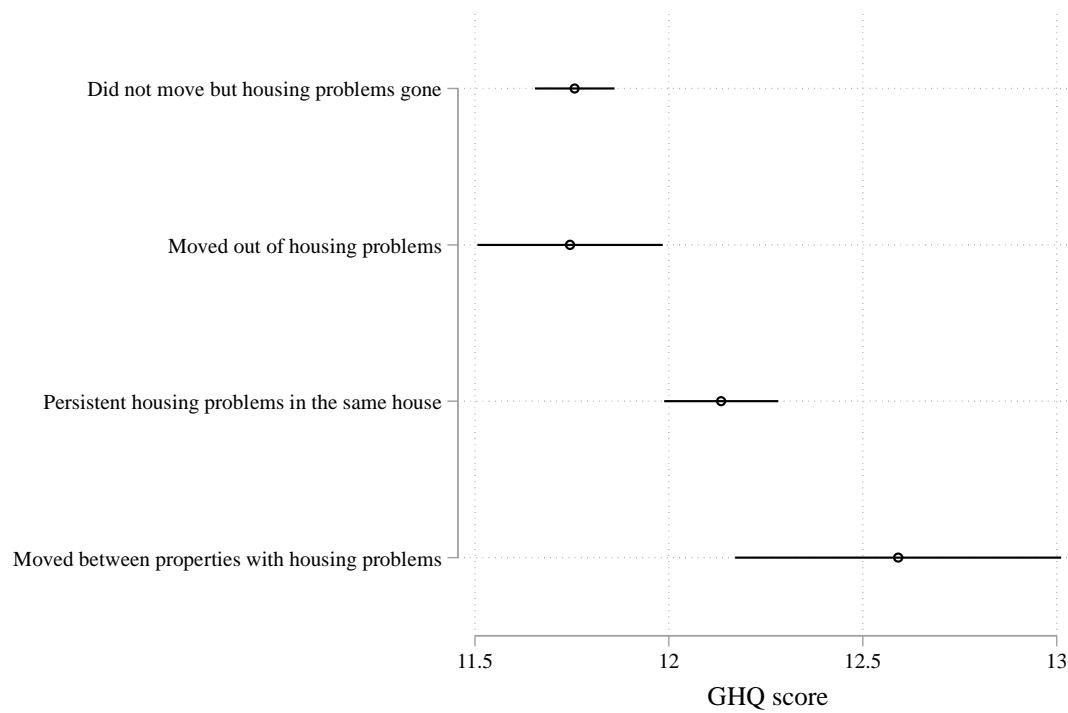
Tables

Table 1: Descriptive statistics for analytic sample

Table 2: Persistent housing problems affect mental health. Data from British Household Panel Survey (1996-2008).

Table 3: Persistent housing problems in the past affects mental health in the present. Data from British Household Panel Survey (1996-2008).

Table 4: Longitudinal association between changes in mental health and changes in exposure to housing problems. Data from British Household Panel Survey (1996-2008).

Table 1: Descriptive statistics for analytic sample

Variable	N	Mean (%)	SD	Min	Max
GHQ	81,741	11.36	5.45	1	36
Presence of housing problems	81,741	20.04%	-	0	1
Density of housing problems	81,741	.22	.31	0	1
Specific housing problems					
Not enough light	81,736	4.93%	-	0	1
Lack of adequate heating	81,731	3.13%	-	0	1
Condensation	81,720	9.09%	-	0	1
Leaky roof	81,670	3.37%	-	0	1
Damp walls, floors, etc.	81,722	6.46%	-	0	1
Rot in windows, floors	81,730	4.99%	-	0	1
Age	81,741	49.57	17.18	19	100
Sex	81,741	1.55	.50	1	2
Equivalised household income	81,741	2372.42	1670.83	0	66216.98
Social renters	81,741	6.71%	-	0	1
Private renters	81,741	14.93%	-	0	1
Own outright	81,741	32.43%	-	0	1
Financial strain	81,741	2.04	.93	1	5
Moved house in last 12 months	81,741	1.08	.26	1	2
Divorced, widowed, or separated	81,741	15.75%	-	0	1
Single	81,741	14.22%	-	0	1

Table 2: Persistent housing problems affect mental health. Data from British Household Panel Survey (1996-2008).

	GHQ (36-point scale)		
Variables	(1)	(2)	(3)
Persistent housing problems between *t* and *t-3*	1.80***	0.92***	0.92***
	(0.11)	(0.11)	(0.11)
Age at date of interview		0.013***	0.014***
		(0.0025)	(0.0025)
Female (baseline = male)		1.31***	1.31***
		(0.066)	(0.066)
Equivalized Household Income (£000s)		0.034*	0.041**
		(0.018)	(0.018)
Tenure type (baseline = mortgage)			
Private rent		0.020	0.039
		(0.12)	(0.12)
Social rent		0.44***	0.45***
		(0.11)	(0.11)
Own outright		-0.10	-0.12
		(0.081)	(0.081)
Financial strain (baseline = living comfortably)			
Doing alright		0.77***	0.76***
		(0.053)	(0.053)
Just about getting by		2.31***	2.31***
		(0.075)	(0.075)
Finding it quite difficult		5.00***	5.00***
		(0.15)	(0.15)
Finding it very difficult		7.94***	7.92***
		(0.29)	(0.29)
Moved house (baseline = did not move)		0.015	0.046
		(0.082)	(0.082)
Marital status (baseline = married or cohabiting)			
Divorced, widowed, or separated		0.26**	0.25**
		(0.10)	(0.100)
Never married		-0.30**	-0.29**
		(0.097)	(0.098)

Regional dummies	N	N	Y
Time dummies	N	N	Y
Constant	11.0***	8.49***	7.98***
	(0.041)	(0.15)	(0.32)
R^2	0.011	0.10	0.10
Person-years	81745	81745	81745
N	16,234	16,234	16,234

Notes: Standard errors are reported in parentheses and adjusted for clustering at the individual level. Y = we adjust for those dummy variables; N = we do not adjust.

* p <0.1, * $p < 0.05$, ** $p < 0.01$

Table 3: Persistent housing problems in the past affects mental health in the present. Data from British Household Panel Survey (1996-2008).

Variables	GHQ (36-point scale)		
	(1)	(2)	(3)
Housing problems in the present at time t	0.68***	0.37***	0.37***
	(0.063)	(0.060)	(0.060)
Persistent housing problems between time t-1 and t-4	1.27***	0.64***	0.65***
	(0.10)	(0.096)	(0.097)
Age at date of interview		0.014***	0.014***
		(0.0025)	(0.0025)
Female (baseline = male)		1.31***	1.31***
		(0.066)	(0.066)
Equivalized Household Income (£000s)		0.034*	0.041**
		(0.018)	(0.018)
Tenure type (baseline = mortgage)			
Private rent		0.0022	0.022
		(0.12)	(0.12)
Social rent		0.42***	0.43***
		(0.11)	(0.11)
Own outright		-0.10	-0.12
		(0.081)	(0.081)
Financial strain (baseline = living comfortably)			
Doing alright		0.76***	0.76***
		(0.053)	(0.053)
Just about getting by		2.30***	2.30***
		(0.075)	(0.075)
Finding it quite difficult		4.99***	4.98***
		(0.15)	(0.15)
Finding it very difficult		7.92***	7.90***
		(0.29)	(0.29)
Moved house (baseline = did not move)		0.027	0.058
		(0.082)	(0.082)
Marital status (baseline = married or cohabiting)			
Divorced, widowed, or separated		0.26**	0.25**
		(0.10)	(0.100)

Never married		-0.30**	-0.29**
		(0.097)	(0.098)
Regional dummies	N	N	Y
Time dummies	N	N	Y
Constant	10.9***	8.46***	7.94***
	(0.042)	(0.15)	(0.32)
R^2	0.012	0.10	0.10
Person-years	81745	81745	81745
N	16,234	16,234	16,234

Notes: Standard errors are reported in parentheses and adjusted for clustering at the individual level. Y = we adjust for those dummy variables; N = we do not adjust.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Longitudinal association between changes in mental health and changes in exposure to housing problems. Data from British Household Panel Survey (1996-2008).

Variables	Change in GHQ between *t* and *t-3* (36-point scale)	
	(1)	(2)
Change in exposure to housing problems between *t* and *t-3*	0.17** (0.056)	0.17** (0.063)
Change in exposure to housing problems between *t* and *t-1*	—	-0.013 (0.063)
Age at date of interview	-0.0027* (0.0016)	-0.0027* (0.0016)
Female (baseline = male)	0.084** (0.039)	0.084** (0.039)
Equivalized Household Income (£000s)	0.036* (0.019)	0.036* (0.019)
Equivalized Household Income at *t-3* (£000s)	-0.014 (0.018)	-0.014 (0.018)
Tenure type (baseline = mortgage)		
Private rent	-0.045 (0.24)	-0.045 (0.24)
Social rent	-0.12 (0.22)	-0.12 (0.22)
Own outright	0.21** (0.092)	0.21** (0.092)
Tenure type at t-3 (baseline = mortgage)		
Private rent at *t-3*	0.061 (0.25)	0.061 (0.25)
Social rent at *t-3*	-0.033 (0.22)	-0.033 (0.22)
Own outright at *t-3*	-0.15 (0.094)	-0.15 (0.094)
Increase financial strain	0.86*** (0.033)	0.86*** (0.033)
Change in marital status (baseline = no change)		

Become married	0.18	0.18
	(0.32)	(0.32)
Become unmarried	-3.28***	-3.28***
	(0.30)	(0.30)
Regional dummies	Y	Y
Time dummies	Y	Y
Constant	-0.58**	-0.58**
	(0.20)	(0.20)
R^2	0.026	0.026
Observations	60,383	60,383
N	14,086	14,086

Notes: Standard errors are reported in parentheses and adjusted for clustering at the individual level. Note that the number of observations is slightly smaller because we restrict this analysis to only people who do not move across this period. Y = we adjust for those dummy variables; N = we do not adjust.
* $p < 0.05$, ** $p < 0.01$

Web Appendix

Figure S1: Long-term association between housing problems and mental health. Data from British Household Panel Survey (1996-2008).

Figure S2: Association between GHQ and lagged persistent housing problems by gender

Table S1: Simulation of weighted measure of persistent housing problems

Table S2: Cumulative, persistent housing problems in the past affect mental health in the present. Data from British Household Panel Survey (1996-2008).

Table S3: Persistent housing problems in the past affects mental health in the present, alternative lag structures

Table S4: Persistent housing problems in the past affects mental health in the present, adjusting for GHQ score 5 years earlier
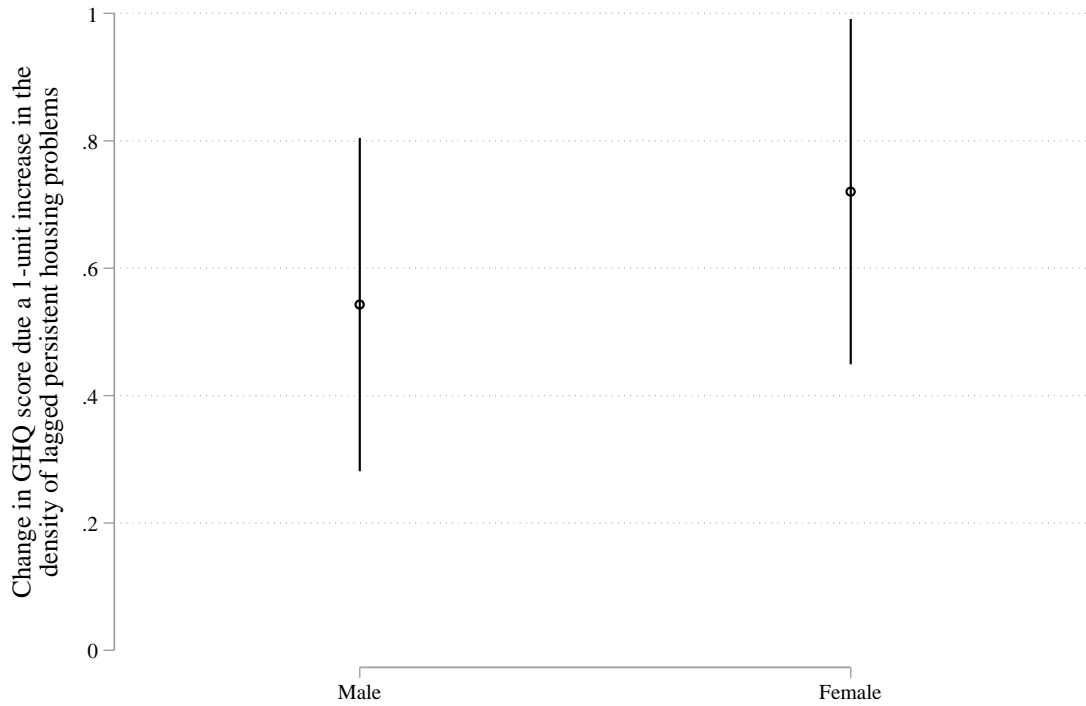
Table S5: Persistent housing problems in the past affects mental health in the present, using hierarchical models clustered by individuals and households.

Figure S1: Long-term association between housing problems and mental health. Data from British Household Panel Survey (1996-2008).
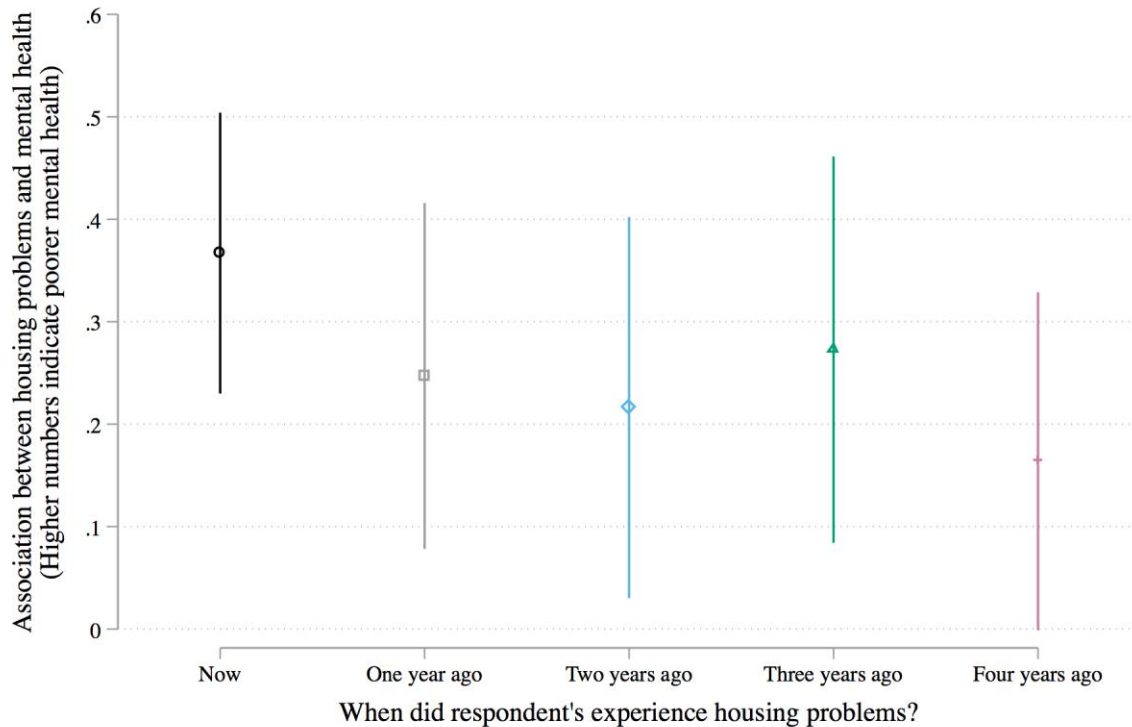
Notes: Model compares people who experienced housing problems in one year but no other years across a five-year period. Each point estimate comes from a different model. Each model adjusts for age, sex, health at baseline, equivalised income in each year, tenure in each year, financial strain in each year, whether people moved in each year, region, and time. Sample is restricted to only those people who did not experience housing problems in any of the years for which we are not observing housing problems. For example, in the model for 'One year ago' respondents are only included if they did not experience housing problems 'two, three, or four years ago' and were not living with housing problems now.

Figure S2: Association between GHQ and lagged persistent housing problems by gender

Notes: Coefficients are based on model 3 from table 3. The only difference is that we estimate two separate models, one for each gender.

Table S1: Simulation of weighted measure of persistent housing problems

In table S1 we calculated a weighted measure of persistent housing problems to address the possibility that experiencing current housing problems may influence current mental health more than experiencing housing problems in the past. However, this approach is not grounded in theory and so here we re-estimate the weighted measure of persistent housing problems using a Monte Carlo simulation procedure to observe whether our results change depending on how we weight past experiences of housing problems. Now the weighting for the housing problems is estimated using this equation:

Weighted housing problem density2000 = ((Housing problem2000 x W_1) + (Housing problem1999 x W_2) + (Housing problem1998 x W_3) + (Housing problem1997 x W_4))/($W_1 + W_2 + W_3 + W_4$)

Here W is a random draw from a uniform distribution [0,1]. We take four random draws (W_1, W_2, W_3, W_4) and calculate the weighted housing problem density measure, again re-scaled from 0 to 1. We then perform this procedure 1000 times (each iteration using another set of random draws from the same distribution) and then re-estimate the weighted regression model 1000 times. Below we report the kernel density of the point estimates and the T-statistic. As expected there is some variation in the size of the association depending on how we weight the past but the vast majority of models have a coefficient > 0.5. Below this figure we also report the distribution of the T-statistic. Here we find that regardless of how we weight past housing problems that our coefficients are much larger than the standard errors of the estimates (>5). These simulations indicate that our results are not contingent on how we weighted the previous experience of housing problems used in this model.

Web Appendix Figure 1: Kernel density of simulated point estimates of association between lagged persistent housing problems and health using different weighting
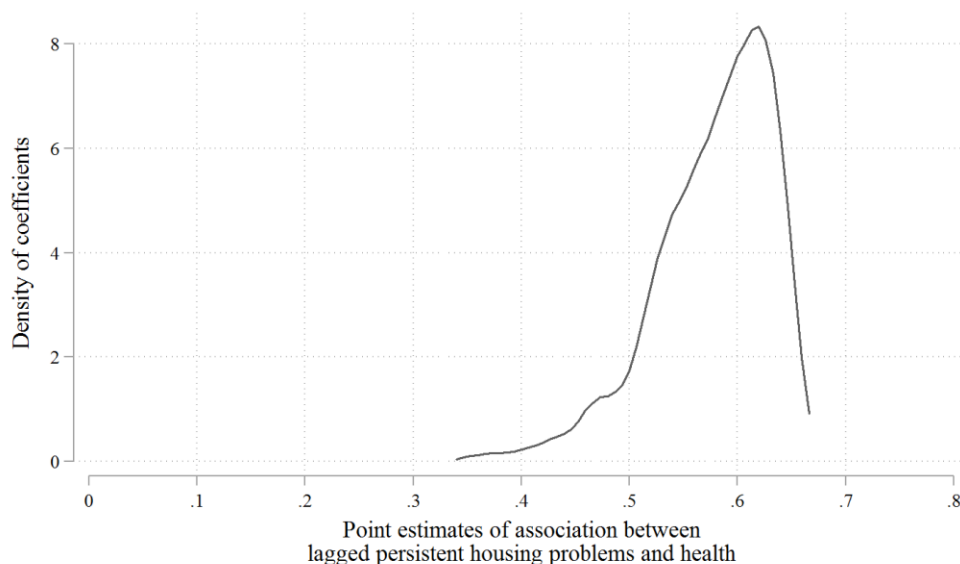
Web Appendix Figure 2: Kernel density of simulated *t*-tests of the association between lagged persistent housing problems and health using different weighting
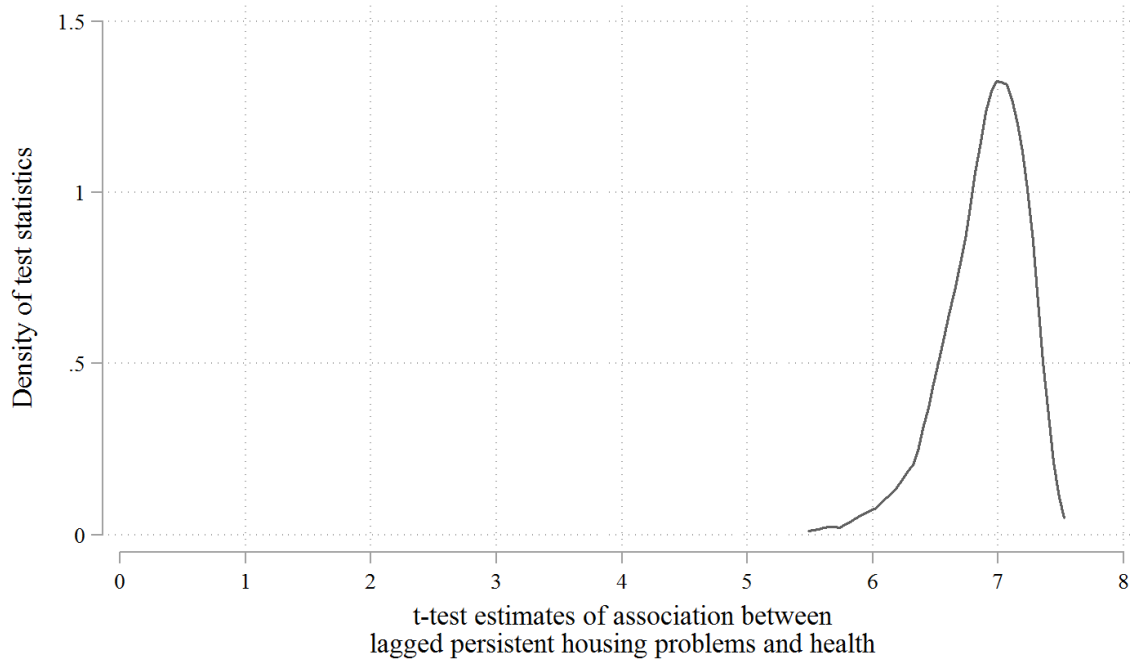
Table S2: Cumulative, persistent housing problems in the past affect mental health in the present. Data from British Household Panel Survey (1996-2008).

	GHQ [36-point scale]
	[1]
Cumulative housing problems in the present at time t	0.18**
	[0.030]
Cumulative, persistent housing problems between t-1 and t-4	0.081**
	[0.012]
Individual covariates	Y
Regional dummies	Y
Time dummies	Y
Constant	7.65**
	[0.30]
Observations	81751
N	16,235

Notes: Standard errors are reported in parentheses and adjusted for clustering at the individual level. Covariates include: age, sex, financial strain, moved property, equivalized income, and tenure type. Y = we adjust for those dummy variables; N = we do not adjust.
* $p < 0.05$, ** $p < 0.01$

Table S3: Persistent housing problems in the past affects mental health in the present, alternative lag structures

Variables	GHQ (36-point scale)		
	(1)	(2)	(3)
Housing problems in the present at time t	0.37***	0.40***	0.35***
	(0.060)	(0.059)	(0.064)
Persistent housing problems between time t-1 and t-4	0.65***	—	—
	(0.097)		
Persistent housing problems between time t-1 and t-3	—	0.54***	—
		(0.089)	
Persistent housing problems between time t-1 and t-5	—	—	0.74***
			(0.11)
Age at date of interview	0.014***	0.014***	0.012***
	(0.0025)	(0.0025)	(0.0027)
Female (baseline = male)	1.31***	1.31***	1.31***
	(0.066)	(0.066)	(0.070)
Equivalized Household Income (£000s)	0.041**	0.040**	0.041**
	(0.018)	(0.018)	(0.019)
Tenure type (baseline = mortgage)			
Private rent	0.022	0.028	0.047
	(0.12)	(0.12)	(0.13)
Social rent	0.43***	0.44***	0.46***
	(0.11)	(0.11)	(0.12)
Own outright	-0.12	-0.12	-0.093
	(0.081)	(0.081)	(0.086)
Financial strain (baseline = living comfortably)			
Doing alright	0.76***	0.76***	0.76***
	(0.053)	(0.053)	(0.056)
Just about getting by	2.30***	2.31***	2.29***
	(0.075)	(0.075)	(0.080)
Finding it quite difficult	4.98***	4.99***	4.89***
	(0.15)	(0.15)	(0.16)
Finding it very difficult	7.90***	7.91***	8.03***
	(0.29)	(0.29)	(0.31)

Moved house (baseline = did not move)	0.058	0.057	0.068
	(0.082)	(0.082)	(0.088)
Marital status (baseline = married or cohabiting)			
Divorced, widowed, or separated	0.25**	0.25**	0.27**
	(0.100)	(0.100)	(0.10)
Never married	-0.29**	-0.29**	-0.28**
	(0.098)	(0.098)	(0.11)
Regional dummies	Y	Y	Y
Time dummies	Y	Y	Y
Constant	7.94***	7.99***	8.03***
	(0.32)	(0.32)	(0.33)
R^2	0.11	0.11	0.11
Person-years	81745	81745	72834
N	16,234	16,234	16,234

Notes: Standard errors are reported in parentheses and adjusted for clustering at the individual level. Y = we adjust for those dummy variables; N = we do not adjust.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table S4: Persistent housing problems in the past affects mental health in the present, adjusting for GHQ score 5 years earlier

	GHQ score (36-point scale)	
	(1)	(2)
Housing problems in the present at time t	0.54**	0.28**
	(0.093)	(0.060)
Persistent housing problems between time $t-1$ and $t-4$	—	0.33**
		(0.090)
Age at date of interview	0.0085**	0.0087**
	(0.0022)	(0.0022)
Female (baseline = male)	0.84**	0.84**
	(0.055)	(0.055)
Equivalized Household Income (£000s)	0.029	0.029
	(0.016)	(0.016)
Tenure type (baseline = mortgage)		
Private rent	-0.032	-0.048
	(0.11)	(0.11)
Social rent	0.27**	0.26**
	(0.095)	(0.095)
Own outright	-0.039	-0.040
	(0.071)	(0.071)
Financial strain (baseline = living comfortably)		
Doing alright	0.52**	0.52**
	(0.049)	(0.049)
Just about getting by	1.74**	1.73**
	(0.068)	(0.068)
Finding it quite difficult	3.83**	3.82**
	(0.14)	(0.14)
Finding it very difficult	6.51**	6.50**
	(0.27)	(0.27)
Moved house (baseline = did not move)	0.066	0.077
	(0.083)	(0.083)
Marital status (baseline = married or cohabiting)		

Divorced, widowed, or separated	0.10	0.10
	(0.085)	(0.085)
Never married	-0.15	-0.15
	(0.086)	(0.086)
GHQ 5 years before	0.35**	0.35**
	(0.0064)	(0.0064)
Regional dummies	Y	Y
Time dummies	Y	Y
Constant	5.38**	5.35**
	(0.28)	(0.28)
R^2	0.21	0.21
Observations	70715	70715
N	13,808	13,808

Notes: Standard errors are reported in parentheses and adjusted for clustering at the individual level. Y = we adjust for those dummy variables; N = we do not adjust.
* $p < 0.05$, ** $p < 0.01$

Table S5: Persistent housing problems in the past affects mental health in the present, using hierarchical models clustered by individuals and households.

	GHQ score (36-point scale)	
	Clustered by household (1)	Clustered by individual (2)
Housing problems in the present at time t	0.38*** (0.055)	0.30*** (0.045)
Persistent housing problems between time t-1 and t-4	0.67*** (0.071)	0.35*** (0.073)
Age at date of interview	0.015*** (0.0015)	0.015*** (0.0021)
Female (baseline = male)	1.31*** (0.035)	1.27*** (0.064)
Equivalized Household Income (£000s)	0.040** (0.013)	-0.0080 (0.013)
Tenure type (baseline = mortgage)		
Private rent	0.026 (0.082)	-0.096 (0.089)
Social rent	0.44*** (0.062)	0.27** (0.081)
Own outright	-0.14** (0.053)	-0.25*** (0.061)
Financial strain (baseline = living comfortably)		
Doing alright	0.75*** (0.045)	0.53*** (0.042)
Just about getting by	2.28*** (0.053)	1.74*** (0.052)
Finding it quite difficult	4.92*** (0.096)	3.73*** (0.088)
Finding it very difficult	7.81*** (0.15)	6.02*** (0.14)
Moved house (baseline = did not move)	0.049 (0.075)	-0.057 (0.061)

Marital status (baseline = married or cohabiting)

Divorced, widowed, or separated	0.25***	0.52***
	(0.055)	(0.074)
Never married	-0.30***	-0.080
	(0.058)	(0.077)
Regional dummies	Y	Y
Time dummies	Y	Y
Constant	7.93***	8.56***
	(0.19)	(0.26)
Observations	81,745	81,745
Clustering units	52,659	16,234

Notes: Standard errors are reported in parentheses and adjusted for clustering at the individual level. Y = we adjust for those dummy variables; N = we do not adjust.
* $p < 0.05$, ** $p < 0.01$