Discussion Paper No. 14-079

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Stefan Angel and Benjamin Bittschi

ZEW
Zentrum für Europäische Wirtschaftsforschung GmbH
Centre for European Economic Research

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Stefan Angel[1]
Statistics Austria

Benjamin Bittschi[2]
ZEW Mannheim
Chair of Public Finance and Public Management, Karlsruhe Institute of Technology (KIT)

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Abstract

Deprived housing conditions have long been recognized as a source of poor health. Nevertheless, there is scant empirical evidence of a causal relationship between housing and health. The literature identifies two different pathways by which housing deprivation affects health, namely, neighborhood effects and the effects of the individual dwelling unit. However, a joint examination of both pathways is absent from the literature. Moreover, endogeneity is a substantial concern in analyses of these two problems. Thus far, studies addressing endogeneity concerns have done so through experimental design or instrumental variables. While the first approach suffers from problems of external validity, we demonstrate the substantial difficulty in identifying robust and reliable instruments for the latter. Consequently, we adopt an alternative strategy to identify the causal effects of housing on health in 21 European countries by estimating fixed-effect models and considering both sources of endogeneity, neighborhoods and dwellings. Furthermore, using the panel dimension of our data, we reveal the accumulation dynamics of poor housing conditions. Our results indicate that living in poor housing is the chief socioeconomic determinant of health over the four-year observation period and that bad housing is a decisive, causal transmission pathway by which socioeconomic status affects health.

Keywords: Housing, Health, Europe, EU-SILC data, Fixed-effects model
JEL-Classification: I14, I18, I38

[1]Address: Statistics Austria, Guglgasse 13, 1110 Vienna, Austria. E-Mail: stefan.angel@statistik.gv.at.
[2]Address: ZEW Centre for European Economic Research, P.O. Box 103443, 68034 Mannheim, Germany. E-Mail: bittschi@zew.de, corresponding author. The authors would like to thank Melissa Engel, Friedrich Heinemann, Thomas Stratmann, Mustafa Yeter and numerous seminar and conference participants for helpful comments and discussion. Stefan Angel gratefully acknowledges financial support by the Theodor Körner Fonds.

1 Introduction

Housing is an important aspect of an individuals standard of living, and poor housing conditions pose a severe challenge to social inclusion. Additionally, housing costs represent a significant share of total household expenditures. In 2007, for instance, approximately 12.5% of the EU27 population lived in households that spent 40% or more of their equivalized disposable income on housing (Eurostat, 2010). Consequently, modern welfare states have developed a multitude of policies to mitigate both the financial burden and the threat of social exclusion posed by overpriced and poor housing conditions. This situation becomes apparent upon examining public spending on housing. For instance, in 2011, the EU27 spent approximately €73.7 billion on housing issues,[1] whereas in the U.S., the annual costs of housing assistance programs amount to approximately $37 billion, as Newman (2008) notes. In addition to the effects of moderating the cost of living, these expenditures are also justified by their positive spillover effects on a variety of desired socioeconomic outcomes, such as improved health, fewer behavioral problems, greater educational attainment, and increased labor force participation.

However, despite the abundance of cross-sectional studies documenting such positive spillover effects, evidence of a causal link between poor housing conditions and socioeconomic outcomes remains surprisingly sparse and, thus, a matter of dispute (Newman, 2008). The main problem is that empirical research using observational data faces the problem of accurate identification concerning the causal link between poor housing conditions and the respective outcome. Individuals choose neighborhoods and dwellings for reasons that are difficult to measure. Thus, empirical analyses will suffer from selection bias if they fail to consider individual characteristics that influence both the outcome variable and the sorting process into neighborhoods and dwellings (Ludwig et al., 2008). Concerning the literature on the outcome of "health", the main topic of this article, a selection mechanism is considered regarding neighborhood effects. That is, many authors devote substantial effort to separating possible effects that may jointly influence health and neighborhood choice (e.g., Katz et al., 2001; Ludwig et al., 2001; Kling et al., 2007; Bilger and Carrieri, 2013). However, this selection mechanism is generally neglected when considering the individual dwelling. Moreover, failing to control for all sources of endogeneity may result in inconsistent estimates of all parameters in the equations considered in the empirical analysis (Wooldridge, 2010).

Therefore, the first aim of this paper is to account for both dimensions of deprived housing, poor neighborhoods and poor dwellings, to derive the causal effects of bad housing on health. To identify the causal effects of housing on health, we analyze four waves of EU-SILC panel data (2005-2008) for 21 European countries. On the one hand, exploiting the panel dimension of our data set allows us to control for unobserved heterogeneity in the selection process for dwellings and for neighborhoods via time- and person-fixed effects. On the other hand, using panel data enables us to address problems of potential simultaneity between health status and relevant socioeconomic control variables, such as income, wealth or education. We demonstrate that this approach is preferable to an IV approach. Finally, using panel data, we can reveal

[1] `http://epp.eurostat.ec.europa.eu/portal/page/portal/social_protection/data/database`

how the accumulation of housing problems over time influences health. In summary, the aim of our research is to improve the empirical estimation strategy applied to observational data to reveal causal pathways between housing deprivation and health and to offer insights into the dynamic effects of deprived housing conditions on health.

2 Poor housing, bad neighborhoods and their relation to health

"Poor housing" is used as an umbrella term. Thus, the expression often fails to clearly define the research object. Certain authors refer to "poor housing" when exploring neighborhood effects, whereas others refer to shortcomings of the individual dwelling unit. Thus, research on the relationship between poor housing and health can be classified into two strands of literature: one strand concerned with the influence of neighborhood effects on health and a second exploring how poor dwelling conditions and insufficient basic facilities affect health. Unfortunately, there is little overlap between these two strands of literature, little cross-referencing and seldom an integrated analysis of the two issues. Therefore, we will review studies from both strands of the literature in this section and provide evidence concerning the effects of bad housing on health.[2]

2.1 Literature on neighborhood effects

As briefly discussed in the introduction, selection bias and endogeneity problems are a major concern in the empirical research on neighborhood effects and health. As Ludwig et al. (2008) write: *"The key problem plaguing nonexperimental approaches is classic omitted-variable bias: people choose or in other ways end up in neighborhoods for reasons that are difficult to measure and that may also correlate with their outcomes."* Therefore, studies attempting to establish a causal link between measures of poor housing and health employ (quasi)experiments or apply IV methods to observational data to circumvent the problems of unobserved heterogeneity.

Prominent examples of approaching this problem using experimental data are papers on the Moving to Opportunity (MTO) program in the U.S. These studies investigated the effects of randomized relocation of deprived families from inner-city, high-poverty areas to low-poverty areas and did not find significant overall effects of relocation on adults' physical health. However, several studies report a substantial reduction in mental health problems in the group of movers (Katz et al., 2001; Ludwig et al., 2001; Kling et al., 2007). The mental health improvements are traced back to stress reduction due to moving *"away from dangerous neighborhoods in which the fear of random violence influenced all aspects of ... live"* (Kling et al. 2007, 102). While the MTO program provides compelling evidence of a causal link between bad housing and certain health measures, the problem of a trade-off between the neat identification of an intervention and the external validity of the research design remains. For instance, Ludwig et al. (2008) admit that the MTO results are only strictly informative concerning individuals eligible for high-rise public housing in the five cities participating in the MTO program at the time of the

[2] In reviewing the related literature, we will concentrate on studies that apply methods able to establish a causal link between bad housing and health. Furthermore, we concentrate on papers from developed countries, leaving aside the issue of the lack of basic facilities in developing countries.

intervention. Moreover, Kling et al. (2007, 86) note that one should be careful in applying these results to populations with different characteristics. Thus, causal inference that allows broader external validity appears desirable.

A second approach to the problem of endogeneity in neighborhood effects is an IV solution, such as that recently advanced by Bilger and Carrieri (2013). Using a rich Italian cross-sectional data set, this study is the first to attempt to solve the selection problem by instrumenting neighborhood conditions using the degree of urbanization to derive the causal effects of neighborhood on health. However, using similar data, we note that the exclusion restriction, i.e., urbanization only influences health via its effect on neighborhoods, is not satisfied (see section 4.2). The epidemiological literature explains such an effect, for instance, through the facilitated transmission of epidemic diseases due to population density (Leon, 2008). However, urbanization may also have positive health effects. The availability of high-quality medical infrastructure is often determined by population density. Thus, to obtain a reliable identification in our analysis, we must dismiss the IV approach and instead rely on a fixed-effects approach.

2.2 Literature on the effect of the dwelling unit

Although both the quasi-experimental and IV approaches account for the endogeneity of the neighborhood, they fail to consider the possibility of an endogenous relationship between poor dwelling unit conditions and health.[3] However, there are strong arguments that an endogeneity problem due to sorting also arises with respect to the link between bad dwellings and health, in a similar vein to neighborhood conditions and health. It is likely that the selection of dwellings is influenced by the same unobservable factors as the selection of neighborhoods and that these factors are correlated with health. For instance, an individuals ability, competence or initiative (Ludwig et al. 2008, 149) might play the same role in finding an adequate neighborhood as in finding an appropriate dwelling.[4] Furthermore, these unobserved effects might not only play a role in finding a dwelling but also in maintaining a healthy living environment. The home's physical adequacy might also be a particular problem for persons who are in need of public housing but who fail to request it. As housing is not an entitlement but a means-tested benefit in many countries, this issue often poses a challenge for eligible persons (Smith, 1990). In the context of public housing, Braconi (2001) estimates that only one-fourth of eligible persons receive housing assistance. This issue is particularly important because the responsible authorities often ensure the physical adequacy of public housing. This adequacy may also be the reason that the MTO papers, with their selection of persons already living in public housing, do not observe an effect of poor housing on physical health.

In the European context, the problem of endogenous dwelling selection might be even more serious than the neighborhood selection problem. For instance, ethnic, racial or socioeconomic segregation is less problematic in Europe than in the U.S. (Musterd, 2005). This difference can be, inter alia, explained by the fact that social-democratic and continental European welfare

[3] Bilger and Carrieri (2013) control for the dwelling conditions but fail to account for endogeneity. The MTO papers do not control for the quality of the dwelling.

[4] For recent evidence on the importance of cognitive ability for health see, e.g., Bijwaard et al. (2013).

states differ in their degree of urban planning and the (de)commodification of housing from liberal welfare states such as the U.S. Although the housing sector is highly heterogeneous across European states (van Kempen and Murie, 2009), the extreme segregation observed in certain studies, such as the one by Kling et al. (2007), in which 85% of the respondents were African-American or Hispanic, is a rare case.

Recent evidence concerning the relationship between physical problems of the individual dwelling unit, specifically lacking basic facilities, and health based on observational data is presented by Pevalin et al. (2008) for the UK and Navarro et al. (2010) for Spain. Pevalin et al. (2008) consider the British Household Panel Survey (BHPS) and use first differencing to control for time-invariant unobserved heterogeneity. However, they do not account for the possible endogeneity of other independent variables, such as income. Moreover, they neglect the issue of neighborhood effects. Navarro et al. (2010) provide evidence on the relationship between physical problems of the dwelling, specifically lacking basic facilities, and health in Spain. They apply a housing deprivation index based on a latent variable model. Assuming reverse causality between their "poor housing" indicators and health, they instrument for these variables. These authors account for neighborhood effects but without considering endogeneity for these variables.

2.3 The transmission of the effects of poor housing to health

At the individual level, the pathways linking housing deprivation with health primarily concern overcrowding, damp and mold, as well as cold- and heat-related issues. Studies report overcrowding in early life as a specific form of housing deprivation (a lack of space) to be associated with, inter alia, respiratory problems (e.g., Britten et al., 1987) or stomach cancer (Barker et al., 1990) in later life. Furthermore, overcrowding results in an increased transmission probability of various infectious diseases. Damp and mold in the dwelling are primarily associated with asthma and other chronic respiratory diseases. Moreover, damp and mold are linked with recurrent headaches, fever, nausea and vomiting, sore throats and poorer mental health. Cold housing is associated with asthma and other respiratory diseases, a lower general health status, an increased use of health services and poorer mental health (see Krieger and Higgins, 2002).

3 Data, Estimation and Identification Strategy

3.1 Data

To answer our research questions, we use four waves of the EU-SILC (EU Survey on Income and Living Conditions) panel data set, covering the years from 2005 to 2008. EU-SILC provides a large set of socioeconomic variables that might confound the effect of housing deprivation on health and thus simplifies the identification strategy. Furthermore, due to their international focus, the data allow a comparison of different EU countries.[5]

[5]Our analysis includes Belgium, Spain, Ireland, Italy, Luxembourg, the Netherlands, Austria, Portugal, Finland, Sweden, the United Kingdom, Bulgaria, Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania,

We use various measures as the dependent variable to capture individual health. We first use self-assessed health (SAH), measured as a binary variable, taking the value one if an individual reports (subjective) bad or very bad health and zero otherwise (fair/good/very good health). We employ limitations to activities of daily living because of health problems (ADL) as the second specification for individual health. This variable takes three possible values: strongly limited, limited and not limited. This variable is converted into a dummy with value one if a person reports any limitations and zero otherwise. Third, we measure health using an indicator reporting a chronic (long-standing) illness or condition. As before, this variable is a dummy with value one if a person mentions a chronic illness and zero otherwise.

The main independent variable of interest, deprived housing conditions, is operationalized via several items. To capture the effects of overcrowding and shortage of space, we include the number of rooms available to a household divided by the equivalized household size.[6] Compared to a simple rooms-per-person-ratio, equivalized household size has the advantage of accounting for household configuration. A problem with overcrowding is that it may be defined differently depending on the respective cultural values and customs. Myers et al. (1996) indicate preferences for greater crowding amongst Asian and Hispanic households irrespective of income level. Assuming that these preferences are time constant, we can control for them using person-fixed effects.

To measure the basic physical structure of a building, we add a dummy variable that takes the value one if the household members live in a building with a leaking roof, damp walls/floors/foundation, or rot in the window frames or floor. Problems with heating conditions are captured through a dummy variable asking whether the household is able to keep the home adequately warm (1=no, 0=yes). We will refer to the first dummy as 'dwelling problems' and to the second dummy as 'heating problems'.

In addition to the quality of the house and heating-related issues, we also employ variables that approximate the hygienic conditions of the respondents. Therefore, we include dummy variables indicating whether the household has a bath or shower in the dwelling (1=no, 0=yes) and an indoor flush toilet for the sole use of the household (1=no, 0=yes). An additional control variable is tenure status, which could be correlated with willingness and/or ability to improve physical housing conditions.

To reduce time-variant unobserved heterogeneity, we control for a large set of socioeconomic variables that are typically found to influence health at the micro level of the individual and the household (see, e.g., Cutler et al. 2008 for an overview of important socioeconomic variables influencing health). To control for the respondents financial resources, we include total disposable household income before social transfers, except for old-age and survivor benefits. However, in one specification, we also exclude income from the rental of property or land and income from interest, dividends and profit from capital investments in unincorporated business from disposable household income. As mentioned in the previous section, we control for

Poland, Romania, Slovakia, Slovenia and Norway.

[6]6Equivalized household size is computed as follows: $1 + 0.5 * HM_{14+} + 0.3 * HM_{13-}$, where HM_{14+} are household members aged 14 years and above and HM_{13-} are household members aged 13 or below.

these income variables separately to test for conditional effects on health, which allows us to reappraise their suitability as instruments for disposable household income. All three income variables are equivalized to household size and adjusted by purchasing power parity to enable a common interpretation of household income across different countries.

To control for education, we include the highest International Standard Classification of Education (ISCED) level attained, measured on a 6-item scale ranging from 0=pre-primary education to 6=second stage of tertiary education (advanced research qualification). Furthermore, we include the individual's age at the time of the interview to capture changes in health status over time. Under the assumption that this relationship is non-linear, we include a quadratic age term. We further control for marital status, measured on a five-item scale that includes never married, married, separated, widowed and divorced. To capture the economic situation of the individuals, irrespective of income and education, we also include self-defined current economic status as a further control variable. This variable is measured on a 9-item scale, including working full time, working part time, unemployed, pupil, student, further training, unpaid work experience, in retirement or in early retirement or has given up business, permanently disabled or/and unfit to work, in compulsory military community or service, fulfilling domestic tasks and care responsibilities, and other inactive person. Economic status is also informative regarding the effect of deprived housing conditions on health, as it reveals the amount of time a person is exposed to bad housing conditions. Therefore, one would expect that, ceteris paribus, retired persons or persons fulfilling domestic tasks would be more prone to report bad health due to deficient housing than employed persons who spend more time outside the dwelling.

3.2 Identification strategy

An initial difficulty concerning our research question is avoiding bias due to unobserved time-constant factors at the person level. The effect of housing on health may be biased due to unobserved, time-invariant factors that are related to both health and housing deprivation. Such factors could include, for instance, unhealthy consumption patterns and preferences that also influence the decision of how to allocate income between housing and other goods, differences in how susceptible individuals are to certain diseases/illness, differences in cognitive abilities/coping strategies concerning awareness of the health-related consequences of bad housing and cultural and political factors that affect both health and types of housing. Our solution to this problem is to estimate fixed-effects panel regression models that allow us to control for unobservable, time-invariant person-fixed effects. To obtain average partial effects at the margins in the fixed-effects specification, we estimate linear probability models (LPM).

As we have discussed, both sorting into neighborhoods and sorting into dwellings can lead to endogeneity in the estimation of the effects of bad housing on health. Unfortunately, the EU-SILC only provides variables for neighborhood effects in the cross-sectional dimension and not in the panel dimension. Therefore, we control for neighborhood problems by reducing our data to a non-mover sample. We can thereby ensure that variation in health status is not caused by changes in neighborhood. To obtain a valid causal inference using fixed-effects models, we

must assume that over the four-year observation period, the characteristics of the neighborhood remain constant, and movers do not differ from non-movers with respect to health. Regarding the latter assumption, see our robustness checks in section 4.5 and Table 15.

Moreover, there is the problem of simultaneity between the socioeconomic control variables and health status. With respect to income, the common assumption is that healthy persons are able to earn more income. Bilger and Carrieri (2013) solve the problem by using an additional instrument, namely income from interest and dividends received and income from the rental of property or land. The authors convincingly argue that these income categories are not the result of activities that require (current) good health status, and thus their use solves the problem of reverse causality. Although these two income categories are apparently widely used instruments (Bilger and Carrieri reference to the work of Ettner (1996), Smith, (1999), and Lindahl, (2005)) it is unclear precisely why these types of income should not influence health while all other types of income do. In other words, if income is important to health status, it is illogical to establish some type of 'non-neutrality of money' i.e., assuming that certain types of income influence health while others do not. By decomposing income into different components, we observe indications that the exclusion restriction for this instrument may also not be satisfied (see section 4.2), and we conclude that identifying convincing instruments for a causal analysis concerning SES effects on health remains a challenging task.

To address potential simultaneity between the SES and health, we instead use lagged values for income and the economic status. Lagged variables are summarized in the vector $Z_{i,t-1}$ will resolve the simultaneity issue if there is no third variable, absent from our regression model, that influences health in the current observation period and SES in the preceding period (Deaton, 1997). In principle, such factors (e.g., genetics, tastes, lifestyle choices) could be present in our model, but by assuming that these factors do not change over the four-year observation period, we can control for them via the fixed effects. The remaining control variables, as described in section 3.1, are summarized by the vector $X_{i,t}$. Thus, we have the following estimation equation:

$$Health_{i,t} = \alpha + \beta_1 Housing_{i,t} + \beta_2 X_{i,t} + \beta_3 Z_{i,t-1} + \mu_i + \nu_{it} \quad (1)$$

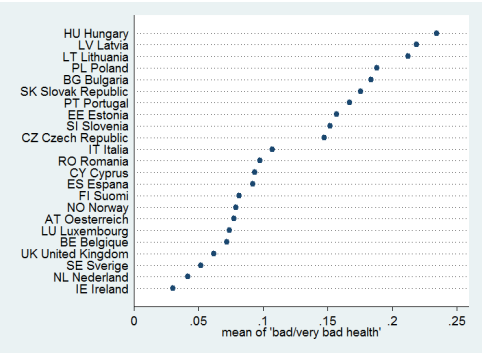
4 Results

4.1 Descriptive statistics

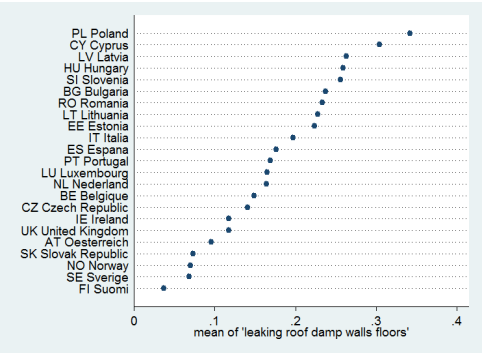
Figure 1 reveals that health and deprived housing conditions vary considerably across European countries. According to EU-SILC, the share of individuals reporting bad or very bad health status varies between approximately 23% in Hungary and 3% in Ireland in 2008 (Figure 1, a). A similar variation can be observed for most of the housing deprivation indicators (Figure 1, b to f). In contrast, only a small fraction of the population in the majority of the countries considered reported lacking an indoor flush toilet or a bath or shower in the dwelling (Figure 1, d and e). This case holds true with the exception of certain Eastern European countries where the percentage of the population lacking such sanitary facilities for sole household use remains

relatively high. Unsurprisingly, crowded living conditions are also more prevalent in these countries (Figure 1, f). However, it also becomes clear that, adjusted for household composition, more than one room is available for each household member in all countries considered.

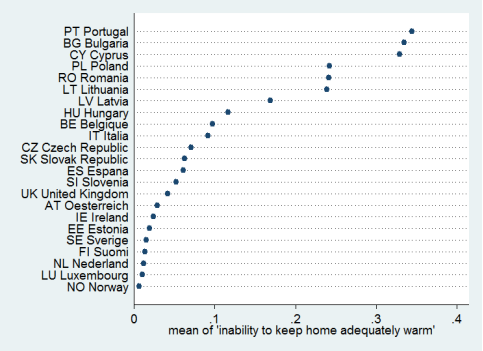
Figure 1: Variation of variables of interest in 2008 (unweighted counts)



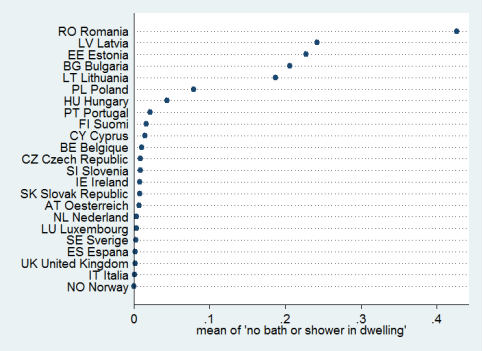
(a) Variation in self-assessed health



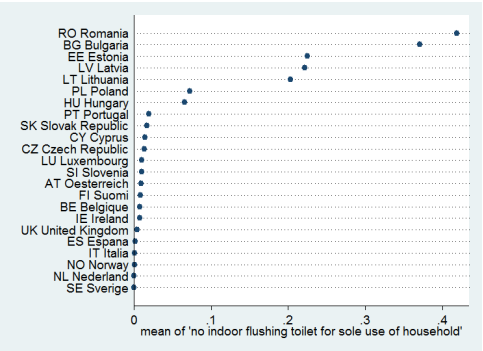
(b) Variation in leaking roof, damp walls, other



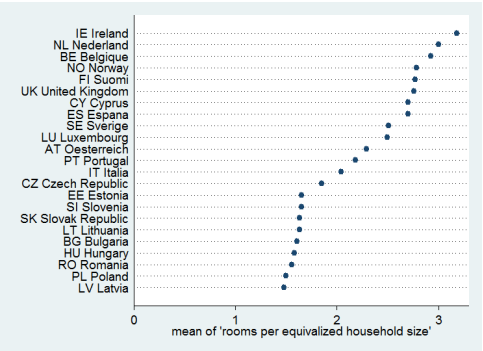
(c) Variation in ability to keep home adequately warm



(d) Variation in bath or shower in dwelling



(e) Variation in indoor flush toilet



(f) Variation in rooms per equivalized household size

Table 1 provides an initial examination of the relationship between housing deprivation and health.[7] Comparing the mean values of various health outcomes conditional on certain

[7] A descriptive overview of all variables used in the analyses, pooled over time and countries, can be found in

housing problems, it becomes evident that poor housing is strongly associated with lower health status. Individuals living in deprived housing consistently report having poorer health relative to individuals living in decent housing. In the extreme case, the difference between the mean value of limitations in activities of daily life between persons with and without dwelling problems amounts to 12.3%. Across all indicators of poor housing, with the exception of overcrowding, this difference always amounts to approximately 10%. Surprisingly, the descriptive results change for overcrowding, which is defined here as less than one room per equivalized household member. With the exception of the SAH, for ADL and chronic diseases, crowding is associated with better health. A potential explanation for this point is that living with many persons is beneficial for individuals experiencing difficulties in managing daily living due to health problems and with chronic diseases, as it increases the probability of an available 'helping hand'.

Table 1: Means of health and housing variables

	(1) SAH	(2) ADL	(3) Chronic
Dwelling problems			
YES	0.200	0.326	0.392
NO	0.115	0.243	0.300
Heating problems			
YES	0.231	0.332	0.395
NO	0.118	0.249	0.308
No bath/shower			
YES	0.247	0.356	0.392
NO	0.125	0.253	0.314
No toilet for sole use			
YES	0.243	0.336	0.384
NO	0.124	0.254	0.314
Overcrowding			
YES	0.138	0.205	0.256
NO	0.131	0.263	0.322
N	355565	355565	355565

4.2 Scrutinizing IV solutions

As exemplified in section 2, establishing a causal relationship between housing and health is not an easy task. One solution is to permit a causal interpretation of regression results using observational data by employing instrumental variables. However, good instruments are notoriously difficult to find. Therefore, before presenting the details of our fixed-effects approach, we will briefly scrutinize one aspect of the IV strategy of Bilger and Carrieri (2013) as described in Appendix A.

section 2.1. Specifically, we will assess whether the exclusion restrictions for their instruments are satisfied for our panel data set and thus whether it would be advisable to proceed with such an IV strategy.

Table 2: Influence of urbanization, income from interests, dividends, rental and property of land on health, pooled OLS and Random Effects LPM

	(1) SAH	(2) ADL	(3) Chronic	(4) SAH	(5) ADL	(6) Chronic
Intermediate	0.002	0.016^{***}	-0.019^{***}	0.000	0.016^{***}	-0.020^{***}
	(1.433)	(8.575)	(−9.363)	(0.213)	(9.653)	(−11.090)
Rural	0.002	0.012^{***}	-0.013^{***}	0.004^{***}	0.013^{***}	-0.010^{***}
	(1.821)	(7.120)	(−6.962)	(3.431)	(9.074)	(−6.359)
Disposable income	-0.000^{***}	-0.000^{***}	-0.000^{***}	-0.000^{***}	-0.000^{***}	-0.000^{***}
	(−8.082)	(−8.650)	(−8.415)	(−7.173)	(−7.670)	(−7.175)
Rental of property/land	-0.000^{***}	-0.000^{***}	-0.000^{***}	-0.000^{***}	-0.000^{***}	-0.000^{***}
	(−6.982)	(−5.426)	(−8.226)	(−5.127)	(−4.103)	(−6.834)
Interests & dividends	-0.000^{**}	−0.000	−0.000	-0.000^{*}	−0.000	−0.000
	(−2.694)	(−1.712)	(−1.298)	(−2.334)	(−1.155)	(−1.704)
X_i	YES	YES	YES	YES	YES	YES
$Z_{i,t-1}$	YES	YES	YES	YES	YES	YES
N	630512	631774	631815	630512	631774	631815

t statistics in parentheses; Standard errors clustered at the household level
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: Influence of urbanization, income from interests, dividends, rental and property of land on health, fixed effects LPM

	(1) SAH	(2) ADL	(3) Chronic	(4) SAH	(5) ADL	(6) Chronic
Intermediate	-0.021^{**}	−0.000	0.020	−0.022	0.002	0.028
	(−3.153)	(−0.031)	(1.661)	(−1.721)	(0.091)	(1.340)
Rural	−0.012	0.014	0.008	-0.028^{*}	0.007	−0.015
	(−1.887)	(1.238)	(0.656)	(−2.270)	(0.356)	(−0.735)
Disposable income	−0.000	-0.000^{**}	−0.000			
	(−1.745)	(−2.808)	(−1.605)			
Lagged disposable income				0.000	−0.000	−0.000
				(0.205)	(−1.301)	(−0.645)
Rental of property/land	0.000^{*}	0.000	0.000	0.000	0.000	−0.000
	(1.963)	(1.782)	(0.822)	(0.491)	(0.274)	(−0.744)
Interests & dividends	−0.000	0.000	−0.000	0.000	0.000^{*}	−0.000
	(−0.335)	(1.742)	(−1.138)	(0.219)	(2.388)	(−0.961)
X_i	YES	YES	YES	YES	YES	YES
$Z_{i,t-1}$	YES	YES	YES	YES	YES	YES
N	630512	631774	631815	359563	361314	361014

t statistics in parentheses; Standard errors clustered at the household level
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The pooled OLS models (columns 1-3) and random effects LPM in Table 2 indicate that neither urbanization, as an instrument for neighborhoods, nor income from the rental of property or land and income from interests and dividends, as an instrument for current income, is truly

absent from a health model, thus violating the exclusion restriction. Table 3 reveals that the degree of urbanization and both types of income also affect fixed-effects LPM (with and without lagged income). Thus, we will retain the methodology described in section 3.2.

4.3 Causal effects of housing on health

Table 4 presents the regression results of equation (1) for the three dependent variables SAH, ADL, and chronic diseases. It becomes evident that living in a dwelling with a leaking roof, damp walls or rot and having limited means to keep the home warm significantly increase the likelihood of being in poor health regardless of the health indicator considered. Concretely, living in a dwelling with physical problems increases the likelihood of reporting poor self-assessed health status by 1.3%. Given an unconditional probability of 13.1%, this value is an increase in the likelihood of being in poor health of 9.2 percentage points. A similar picture emerges for the other health indicators. Facing dwelling problems increases the likelihood of suffering from limitations in daily activities by 2.2% and of suffering from a chronic disease by 3.2%. With respect to the unconditional probability of both health limitations (ADL: 25.9%, chronic: 31.8%), this value represents an increase in the probability of reporting health problems of 8.5 (ADL) and 10.6 percentage points (chronic diseases).

Heating problems, the second indicator of bad housing that is statistically significant, increase the likelihood of reporting poor self-assessed health by 1.3% and of reporting chronic illnesses by 1.2%. Similar to the outcome for dwelling problems, this value is an increase of 9.2 percentage points in the probability of reporting poor self-assessed health and an increase of 4.1 percentage points in the probability of suffering from a chronic illness due to heating problems.

In contrast, the affordability of adequate heating does not appear to influence limitations in daily activities. Furthermore, overcrowding, lack of a bath or shower for the sole use of the household, and the unavailability of a toilet for the sole use of the household do not have a statistically significant effect on health measures. It appears likely that the statistical and economic insignificance of overcrowding is a consequence of our data and methodology. Identification via fixed-effects requires variation in the control variable within the observation unit. In the case of overcrowding, the standard deviation of the within-variation is only 0.14, as the average dwelling has 2.09 rooms. To identify overcrowding effects, particularly for children, longer observation periods therefore appear to be necessary.

To compare the effect size of the statistically significant variables indicating a relationship between deprived housing conditions and other variables determining SES, we computed standardized beta coefficients (see Table 5). Drawing this comparison using the two most widely considered aspects of socioeconomic status, income and education, it becomes apparent that neither exerts a statistically significant influence on health. Clearly, as in the case of overcrowding, this result may, to some extent, be a consequence of a small within-variation underlying the fixed-effects method. Concerning income, this result can be explained by our observation of equivalized household-level income, which entails the possibility for other household members to hedge financial losses. Furthermore, over such a brief period, it is likely that declines in income

Table 4: Regression results

	(1) SAH	(2) ADL	(3) Chronic
Overcrowding	−0.005	0.004	0.004
	(−1.609)	(1.088)	(0.968)
Dwelling problems	0.013***	0.022***	0.032***
	(5.153)	(6.953)	(10.233)
Heating problems	0.012***	0.006	0.013**
	(3.470)	(1.512)	(3.197)
No bath/shower	0.004	0.001	0.002
	(0.339)	(0.060)	(0.184)
No toilet for sole use	0.011	−0.008	0.008
	(0.987)	(−0.699)	(0.664)
X_i	YES	YES	YES
$Z_{i,t-1}$	YES	YES	YES
N	355565	355565	355565
adj. R^2	0.001	0.001	0.003

t statistics in parentheses; Standard errors clustered at the household level
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

could be compensated by social transfers. Concerning education, few individuals are observed completing their education in a four-year period, and positive health effects are unlikely to materialize in such a brief period of time. In contrast, concerning the economic significance of the SAH in the short run, the effects of education on health appear to be adverse, which may be due to the stress-induced effects of completing an educational degree. This interpretation may be supported by the observation that the effect vanishes when a stronger cutoff is applied to the SAH (see section 4.5 and Table 13). Therefore, the comparison of housing deprivation indicators and other socioeconomic control variables demonstrates that, in the short run, deprived housing conditions are the most adverse aspect of socioeconomic status in determining health. In comparison, the transmission pathways of the classical socioeconomic control variables, such as income and education, appear to have long-run effects.

Table 5: Regression results standardized beta coefficients

	(1) SAH	(2) ADL	(3) Chronic
Dwelling problems	0.015***	0.020***	0.027***
	(5.153)	(6.953)	(10.233)
Heating problems	0.011***	0.005	0.009**
	(3.470)	(1.512)	(3.197)
Disposable income	−0.000	0.001	−0.002
	(−0.194)	(0.431)	(−0.869)
Education, ref. category: pre-primary education			
Primary education	0.043	−0.028	−0.038
	(0.988)	(−0.716)	(−1.174)
Low sec. education	0.054	−0.033	−0.039
	(1.084)	(−0.734)	(−1.068)
Upper sec. education	0.069	−0.042	−0.045
	(1.088)	(−0.733)	(−0.956)
Post-sec. non-tert. education	0.031	−0.013	−0.016
	(1.267)	(−0.585)	(−0.877)
Tertiary education	0.054	−0.033	−0.029
	(1.100)	(−0.738)	(−0.801)
X_i	YES	YES	YES
$Z_{i,t-1}$	YES	YES	YES
N	355565	355565	355565
adj. R^2	0.001	0.001	0.003

Standardized beta coefficients; t statistics in parentheses; Standard errors clustered at the household level
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.4 Accumulated effects of bad housing

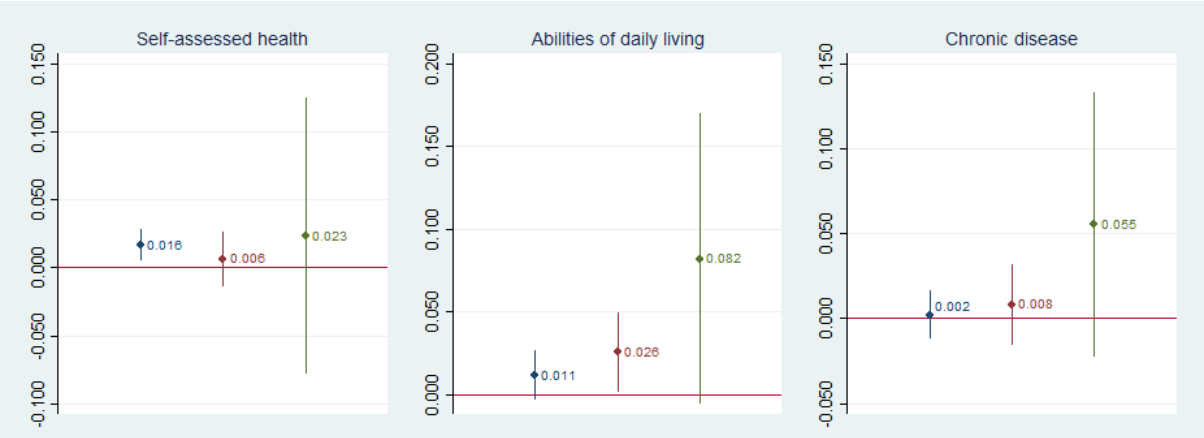
We divide our sample into three parts to investigate how the occurrence of dwelling and heating problems influences health over time in greater detail. The first sample contains individuals suffering from either dwelling or heating problems only once. The second sample covers individuals suffering from these problems twice, and the third sample includes individuals affected three times. The division of the sample offers interesting insights into the dynamics of the transmission process of the effect of housing problems on various health outcomes. However, it also considerably reduces the sample size and thus the efficiency of the estimates. Therefore, in interpreting the effects, we will emphasize economic significance. Nevertheless, the 95% confidence intervals are graphically depicted. Figure 2 depicts the results for the effects of dwelling problems on health and figure 3 for the effects of heating problems on health.

The left plot in figure 2 depicts the effect of dwelling problems on SAH. It becomes apparent that a unique occurrence of dwelling problems exerts a slightly higher influence on SAH (point estimate of 0.016) than for the whole sample (0.013). This effect becomes nearly zero for

dwelling problems experienced on two occasions but increases to 0.023 in the event of a threefold occurrence. The relatively large effect of non-recurring dwelling problems and the temporary reduction in the case of individuals affected twice may indicate mental health problems due to the onset of deteriorated housing conditions and transitory habituation effects. However, for long-term exposure to poor physical housing conditions, the effect size rebounds.

The central and the right plots in the figure depict the effects of dwelling problems on ADL and chronic diseases. Both indicators represent rather severe health indicators, and thus the trends in effect size resemble one another. The occurrence of dwelling problems on a single occasion exhibits a moderate effect on ADL and nearly no impact on chronic diseases. However, the probability of health problems increases drastically in individuals frequently exposed to poor housing conditions.

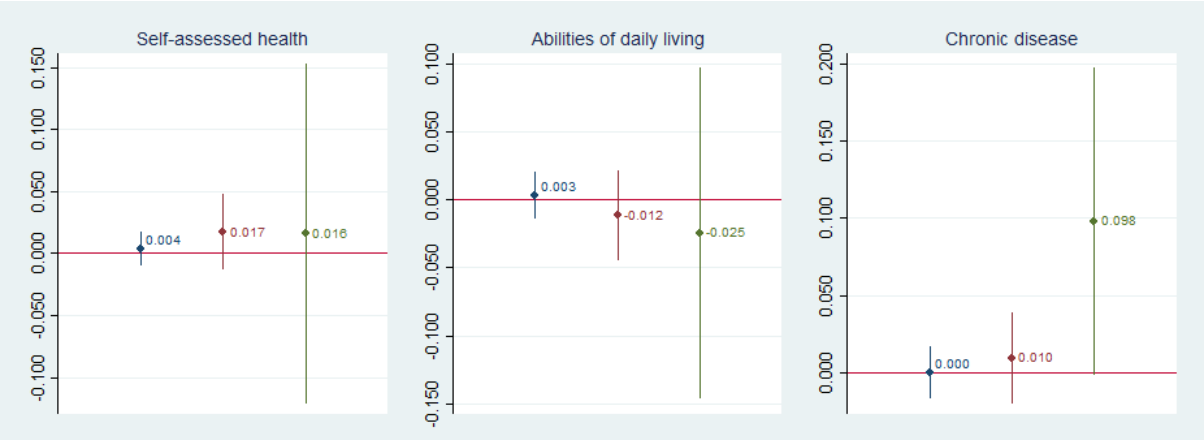
Figure 2: Effects of accumulated dwelling problems on health



All coefficients result from linear fixed-effects models, as specified in section 3.2. The first line of each plot stems from the sample of individuals exposed to dwelling problems on a single occasion (N=57,803). The second line stems from the subsample of individuals exposed twice (N=39,194) and the third line from the subsample of individuals exposed three times (N=13,725). The line itself represents the 95% confidence interval. A total of 3,642 individuals are exposed to housing problems on four occasions, and 241,201 individuals never experience housing problems. Detailed regression results for all coefficients are available upon request.

Concerning heating problems, the effects on chronic diseases resemble the effects observed for dwelling problems (see the right plot of figure 3). While the experience of single or two-period heating problems has no effect or only modest effects on the probability of suffering from a chronic disease, this effect is rather large for those individuals enduring extended heating problems. That is, exposure to heating problems over a three-year period increases the probability of chronic disease by 9.8%. In contrast to dwelling problems, the effect of heating problems on SAH does not exhibit transitory habituation effects. Rather, the effects for two- and three-year exposed individuals are 0.017 and 0.018, or nearly equal. A single experience of heating problems has almost no effect on SAH. Finally, the statistical insignificance of heating problems on ADL is also reflected in the effect of accumulated heating problems, where the effect of heating problems on ADL is reversed.

Figure 3: Effects of accumulated heating problems on health



All coefficients result from linear fixed-effects models as specified in section 3.2. The first line of each plot stems from the sample of individuals exposed to dwelling problems on one occasion (N=43,581). The second line stems from the subsample of individuals exposed twice (N=23,656) and the third line from the subsample of individuals exposed to dwelling problems on three occasions (N=7,322). The line itself represents the 95% confidence interval. A total of 2,010 individuals are exposed to housing problems four times, and 278,996 individuals never experience housing problems. Detailed regression results for all coefficients are available upon request.

4.5 Robustness checks

We applied several checks to assess the robustness of our results. We altered the variable of interest in our investigation by applying an additive housing deprivation index, i.e., adding the number of problems instead of the separate items. Changing the specification of housing deprivation did not alter our results (see Table 9).

Furthermore, we modified the income variable by replacing equivalized personal income with a dummy variable for income poverty. This dummy takes a value of one if a household receives less than 60% of the median equivalized income (see Table 10). Additionally, we used equivalized disposable income measured in country-specific quintiles. Using quintiles has the advantage of avoiding a conversion of country-specific currencies and reducing the issue of possible measurement error. Further, as the unit of measurement is the household, the endogeneity problem between health and income is also limited. These specification changes concerning income did not alter our results (see Table 11).

Concerning the regression method, we also estimated logistic panel regressions using fixed effects (see Table 12). Moreover, we varied the cutoff point of the dependent variables SAH and ADL. In the case of SAH, we consider, on the one hand, only very bad health status as the reference category (Table 13, stronger SAH) and allocate, on the other hand, fair health status to self-assessed bad/very bad health (see Table 13, weaker SAH). In the case of ADL, we also apply a stronger cutoff criterion and consider only severely limited persons (Table 13, stronger ADL). Again, these modifications do not substantially affect our results.

In addition, we investigated whether our results are driven by poor (Eastern) European countries. Dropping such countries also does not change the substance of the results (see Table 14 for a joint exclusion of Bulgaria, Poland, Portugal and Romania; results for the exclusion of

single countries are available upon request).

Finally, our strategy of controlling for neighborhood effects by concentrating on a non-mover sample depends crucially on the assumption that movers do not differ from non-movers with respect to health status. If persons with worse health status were more likely (less likely) to move, we would underestimate (overestimate) the effect of housing on health, as healthier (unhealthier) individuals would be overrepresented in our sample. Our strategy would thus suffer from selection bias. We test this assumption by regressing a LPM of various health variables (SAH, ADL and the chronic disease dummy) on a dummy variable indicating whether a person has moved. Table 15 in the Appendix reports the results. Neither poor SAH nor limitations in ADL influence moving probabilities. However, individuals with a chronic disease have a 0.2% increased probability of moving. Thus, regarding chronic diseases, our approach will tend to underestimate the effect of bad housing on health, as chronically ill persons are slightly underrepresented in our sample. This result may be because certain chronically ill persons (e.g., dialysis patients) may choose their residence according to available medical facilities. In summary, the results are robust to various changes in the specification.

5 Discussion and conclusion

Regarding individual health, we can conclude that bad housing conditions certainly have an adverse effect. Our analysis provides evidence of a causal effect of bad housing on general health. This result is in contrast to previous studies such as Kling et al. (2007) that fail to identify significant overall effects on adult physical health. Moreover, we note that in our sample, decent housing is a more important determinant of health than education or income. Additionally, we provide evidence that the probability of suffering from a chronic disease increases sharply when housing problems accumulate over time. In contrast, poor housing conditions deteriorate subjective health relatively rapidly. In identifying these effects, we account for the possible endogeneity of both neighborhood conditions and (in)adequacy of housing conditions.

From a policy perspective, our findings can justify measures to improve housing conditions for individuals in deprived living conditions, as these conditions have a causal effect on health. To offer policy guidance concerning how to implement such measures, further research on the costs and benefits and the cost-effectiveness of housing policies would be desirable, as those topics are currently little researched. Recent evidence concerning housing subsidies in the U.S. indicates that the effect of the overall level of net benefits is not clear, although it appears likely that the program under study (Section 8 housing vouchers) delivers positive net benefits (Carlson et al. 2011). Furthermore, there is evidence of heterogeneous effects across countries. By fitting several pooled models that include country dummies and interactions with dwelling problems, we found significant differences in the strength of the effect on self-assessed health for certain countries (i.e., stronger effects in Bulgaria [3 pct. points] and weaker effects [-4 pct. points] in Ireland compared to the reference country of Belgium and overall significance for the inclusion of such interactions in the pooled models via LR-tests). From a cross-country comparative policy perspective, it could be worthwhile to investigate macro factors determining

the variation in effect strength in greater detail. The data source we used could provide a strong basis for future analyses that draw international comparisons concerning country-specific variations in the relationship between bad housing and health.

While this paper can provide novel insights into the causal relationship between bad housing and health, it also faces certain limitations. First, regarding inadequate housing, we fail to disentangle the individual causes most responsible for bad housing, as our main variable of inadequate housing is an aggregate of various items (e.g., mold, dampness, leaking roof). Moreover, this variable is self-reported. Therefore, measurement error could be an issue if the respondents were uninformed regarding possible problems affecting the quality of their housing, e.g., the ability to identify mold and to be informed of effective remedies. Due to our estimation method via fixed effects, the estimates reflect the effects of temporary poor housing. While this method is helpful in establishing a causal relationship between poor housing and health, it may underestimate the effects of long-term exposure to poor housing.

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A Full tables

Table 6: Summary statistics

Variable	Mean	Std. Dev.	N
Dependent variables - Health			
Self-assessed general health (SAH), 1=bad or very bad SAH	0.131	0.338	355565
Limitation in daily activities due to health problems (ADL), 1=YES	0.259	0.438	355565
Chronic or long-standing illness or condition (Chronic), 1=YES	0.318	0.466	355565
Independent variables			
Housing deprivation and housing status			
Rooms per equivalized household member (Overcrowding)	2.091	0.970	355565
Leaking roof, damp, rot, 1=YES	0.194	0.395	355565
Ability to keep home adequately warm (Heating problems), 1=NO	0.116	0.320	355565
Bath or shower in dwelling, 1=NO	0.055	0.227	355565
Indoor flushing toilet for sole use of household, 1=NO	0.060	0.238	355565
Owner	0.811	0.392	355565
Tenant or subtenant, rent at prevailing or market rate	0.067	0.250	355565
Accommodation rented at reduced rate (lower than market price)	0.046	0.210	355565
Accommodation is provided free	0.076	0.265	355565
Education			
Pre-primary education	0.009	0.093	355565
Primary education	0.137	0.343	355565
Lower secondary education	0.186	0.389	355565
(Upper) secondary education	0.452	0.498	355565
Post-secondary non-tertiary education	0.039	0.193	355565
1st & 2nd stage of tertiary education	0.178	0.383	355565
Income			
Disposable income	12041.163	12753.753	355559
Income from rental of a property or land	207.594	2003.544	355559
Interests, dividends, profit from capital investments	346.821	7499.798	355565
Age and family background			
Age (at the date of the interview)	48.705	17.756	355565
Never married	0.249	0.433	355565
Married	0.587	0.492	355565
Separated	0.011	0.103	355565
Widowed	0.095	0.293	355565
Divorced	0.058	0.234	355565
Self-defined current economic status			
Working full-time	0.442	0.497	355565
Working part-time	0.060	0.238	355565
Unemployed	0.046	0.210	355565
Pupil, student, further training, unpaid work experience	0.069	0.253	355565
In (early) retirement or has given up business	0.254	0.435	355565
Permanently disabled or/and unfit to work	0.039	0.193	355565
In compulsory military community or service	0.001	0.031	355565
Fulfilling domestic tasks or care responsibilities	0.067	0.251	355565
Other inactive person	0.021	0.145	355565

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... table 6 continued

Variable	Mean	Std. Dev.	N
Countries, percentage of observations			
Austria	0.044	0.205	355565
Belgium	0.041	0.198	355565
Bulgaria	0.026	0.160	355565
Cyprus	0.031	0.174	355565
Czech Republic	0.097	0.295	355565
Estonia	0.031	0.175	355565
Spain	0.096	0.295	355565
Finland	0.020	0.141	355565
Hungary	0.066	0.249	355565
Ireland	0.019	0.137	355565
Italy	0.075	0.263	355565
Lithuania	0.036	0.186	355565
Luxemburg	0.046	0.209	355565
Latvia	0.017	0.130	355565
Netherlands	0.012	0.107	355565
Norway	0.020	0.140	355565
Poland	0.124	0.329	355565
Portugal	0.015	0.123	355565
Romania	0.034	0.180	355565
Sweden	0.018	0.132	355565
Slovenia	0.032	0.175	355565
Slovakia	0.049	0.216	355565
UK	0.052	0.222	355565

Table 7: Baseline regression results

	SAH	ADL	Chronic
Housing deprivation			
Overcrowding	−0.005	0.004	0.004
	(−1.609)	(1.088)	(0.968)
Dwelling problems	0.013***	0.022***	0.032***
	(5.153)	(6.953)	(10.233)
Heating problems	0.012***	0.006	0.013**
	(3.470)	(1.512)	(3.197)
No bath/shower	0.004	0.001	0.002
	(0.339)	(0.060)	(0.184)
No toilet for sole use	0.011	−0.008	0.008
	(0.987)	(−0.699)	(0.664)
Tenure status, ref. category: owner			
Tenant market rate	−0.006	−0.018	−0.016
	(−0.744)	(−1.562)	(−1.418)
Tenant reduced rate	0.017	0.004	0.019
	(1.951)	(0.297)	(1.530)
Free accommodation	0.006	0.005	0.018*
	(0.849)	(0.604)	(1.975)

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... table 7 continued

	SAH	ADL	Chronic
Education, ref. category: pre-primary education			
Primary education	0.042	−0.036	−0.051
	(0.988)	(−0.716)	(−1.174)
Low sec. education	0.047	−0.037	−0.047
	(1.084)	(−0.734)	(−1.068)
Upper sec. education	0.047	−0.037	−0.042
	(1.088)	(−0.733)	(−0.956)
Post-sec. non-tert. education	0.055	−0.030	−0.039
	(1.267)	(−0.585)	(−0.877)
Tertiary education	0.048	−0.038	−0.036
	(1.100)	(−0.738)	(−0.801)
Income			
Disposable income	−0.000	0.000	−0.000
	(−0.194)	(0.431)	(−0.869)
Age			
Age	−0.005**	−0.015***	−0.008**
	(−2.709)	(−5.512)	(−2.960)
Age squared	0.000**	0.000***	0.000***
	(2.741)	(7.110)	(7.138)
Marital status, ref. category: single			
Married	−0.003	−0.003	−0.018*
	(−0.510)	(−0.294)	(−1.964)
Separated	0.009	−0.019	−0.005
	(0.766)	(−1.182)	(−0.326)
Widowed	0.026*	0.027	0.005
	(2.411)	(1.933)	(0.377)
Divorced	0.007	0.007	0.000
	(0.801)	(0.596)	(0.020)
Current economic status, ref. category: full-time work			
Part-time work	−0.000	−0.007	−0.010
	(−0.084)	(−1.356)	(−1.758)
Unemployed	−0.000	−0.002	0.001
	(−0.129)	(−0.410)	(0.195)
Pupil, student, further training	−0.006	−0.008	0.000
	(−1.884)	(−1.291)	(0.052)
(Early) retirement	−0.018**	−0.013	0.002
	(−2.900)	(−1.661)	(0.207)
Unable/unfit to work	−0.027**	−0.010	−0.002
	(−2.723)	(−0.996)	(−0.271)
Military or community service	−0.011	−0.030	−0.015
	(−0.728)	(−1.432)	(−0.672)
Domestic tasks or care	0.002	−0.009	−0.014
	(0.484)	(−1.220)	(−1.947)
Other inactive person	−0.014*	−0.008	−0.004
	(−2.018)	(−0.980)	(−0.525)
Constant	0.173**	0.449***	0.187*
	(3.087)	(5.591)	(2.440)
N	355565	355565	355565
adj. R^2	0.001	0.001	0.003

t statistics in parentheses; Standard errors clustered at the household level
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8: Baseline regression results - Beta coefficients

	SAH	ADL	Chronic
Housing deprivation			
Overcrowding	−0.014	0.010	0.008
	(−1.609)	(1.088)	(0.968)
Dwelling problems	0.015***	0.020***	0.027***
	(5.153)	(6.953)	(10.233)
Heating problems	0.011***	0.005	0.009**
	(3.470)	(1.512)	(3.197)
No bath/shower	0.003	0.000	0.001
	(0.339)	(0.060)	(0.184)
No toilet for sole use	0.007	−0.005	0.004
	(0.987)	(−0.699)	(0.664)
Tenure status, ref. category: owner			
Tenant market rate	−0.004	−0.010	−0.009
	(−0.744)	(−1.562)	(−1.418)
Tenant reduced rate	0.011	0.002	0.009
	(1.951)	(0.297)	(1.530)
Free accommodation	0.005	0.003	0.010*
	(0.849)	(0.604)	(1.975)
Education, ref. category: pre-primary education			
Primary education	0.043	−0.028	−0.038
	(0.988)	(−0.716)	(−1.174)
Low sec. education	0.054	−0.033	−0.039
	(1.084)	(−0.734)	(−1.068)
Upper sec. education	0.069	−0.042	−0.045
	(1.088)	(−0.733)	(−0.956)
Post-sec. non-tert. education	0.031	−0.013	−0.016
	(1.267)	(−0.585)	(−0.877)
Tertiary education	0.054	−0.033	−0.029
	(1.100)	(−0.738)	(−0.801)
Income			
Disposable income	−0.000	0.001	−0.002
	(−0.194)	(0.431)	(−0.869)
Age			
Age	−0.262**	−0.598***	−0.301**
	(−2.709)	(−5.512)	(−2.960)
Age squared	0.320**	0.834***	0.778***
	(2.741)	(7.110)	(7.138)
Marital status, ref. category: single			
Married	−0.005	−0.003	−0.019*
	(−0.510)	(−0.294)	(−1.964)
Separated	0.003	−0.004	−0.001
	(0.766)	(−1.182)	(−0.326)
Widowed	0.023*	0.018	0.003
	(2.411)	(1.933)	(0.377)
Divorced	0.005	0.004	0.000
	(0.801)	(0.596)	(0.020)

Continued on next page...

... table 8 continued

	SAH	ADL	Chronic
Current economic status, ref. category: full-time work			
Part-time work	−0.000	−0.004	−0.005
	(−0.084)	(−1.356)	(−1.758)
Unemployed	−0.000	−0.001	0.000
	(−0.129)	(−0.410)	(0.195)
Pupil, student, further training	−0.005	−0.005	0.000
	(−1.884)	(−1.291)	(0.052)
(Early) retirement	−0.023**	−0.013	0.002
	(−2.900)	(−1.661)	(0.207)
Unable/unfit to work	−0.016**	−0.004	−0.001
	(−2.723)	(−0.996)	(−0.271)
Military or community service	−0.001	−0.002	−0.001
	(−0.728)	(−1.432)	(−0.672)
Domestic tasks or care	0.002	−0.005	−0.008
	(0.484)	(−1.220)	(−1.947)
Other inactive person	−0.006*	−0.003	−0.001
	(−2.018)	(−0.980)	(−0.525)
N	355565	355565	355565
adj. R^2	0.001	0.001	0.003

Standardized beta coefficients; t statistics in parentheses; Standard errors clustered at the household level
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

B Tables for robustness checks

Table 9: Additive housing deprivation index

	SAH	ADL	Chronic
Housing deprivation			
Overcrowding	−0.005	0.004	0.004
	(−1.583)	(1.104)	(0.979)
Housing deprivation index	0.012***	0.012***	0.020***
	(6.553)	(5.501)	(9.179)
Tenure status, ref. category: owner			
Tenant market rate	−0.006	−0.018	−0.017
	(−0.791)	(−1.591)	(−1.461)
Tenant reduced rate	0.017	0.003	0.019
	(1.896)	(0.266)	(1.484)
Free accommodation	0.006	0.005	0.018
	(0.820)	(0.594)	(1.955)
Education, ref. category: pre-primary education			
Primary education	0.042	−0.037	−0.052
	(0.984)	(−0.734)	(−1.192)
Low sec. education	0.046	−0.038	−0.048
	(1.081)	(−0.754)	(−1.088)
Upper sec. education	0.047	−0.038	−0.043
	(1.085)	(−0.754)	(−0.977)
Post-sec. non-tert. education	0.055	−0.031	−0.041
	(1.261)	(−0.609)	(−0.904)
Tertiary education	0.047	−0.039	−0.037
	(1.096)	(−0.761)	(−0.826)
Income			
Disposable income	−0.000	0.000	−0.000
	(−0.197)	(0.437)	(−0.866)
Age			
Age	−0.005**	−0.015***	−0.008**
	(−2.687)	(−5.501)	(−2.948)
Age squared	0.000**	0.000***	0.000***
	(2.747)	(7.133)	(7.160)
Marital status, ref. category: single			
Married	−0.003	−0.003	−0.018*
	(−0.500)	(−0.304)	(−1.967)
Separated	0.009	−0.019	−0.005
	(0.761)	(−1.198)	(−0.343)
Widowed	0.026*	0.027	0.005
	(2.401)	(1.920)	(0.363)
Divorced	0.007	0.007	−0.000
	(0.794)	(0.569)	(−0.008)
Current economic status, ref. category: full-time work			
Part-time work	−0.000	−0.007	−0.010
	(−0.090)	(−1.339)	(−1.741)
Unemployed	−0.001	−0.002	0.001
	(−0.164)	(−0.425)	(0.165)
Pupil, student, further training	−0.006	−0.008	0.000
	(−1.899)	(−1.281)	(0.060)

Continued on next page...

... table 9 continued

	SAH	ADL	Chronic
(Early) retirement	−0.018**	−0.014	0.002
	(−2.906)	(−1.674)	(0.195)
Unable/unfit to work	−0.027**	−0.009	−0.002
	(−2.716)	(−0.975)	(−0.239)
Military or community service	−0.011	−0.030	−0.015
	(−0.733)	(−1.433)	(−0.674)
Domestic tasks or care	0.002	−0.008	−0.014
	(0.483)	(−1.200)	(−1.929)
Other inactive person	−0.014*	−0.008	−0.004
	(−2.021)	(−0.959)	(−0.505)
Constant	0.170**	0.445***	0.184*
	(3.028)	(5.550)	(2.392)
N	355565	355565	355565
adj. R^2	0.001	0.001	0.003

t statistics in parentheses; Standard errors clustered at the household level
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 10: Income poverty

	SAH	ADL	Chronic
Housing deprivation			
Overcrowding	−0.005	0.004	0.004
	(−1.606)	(1.091)	(0.964)
Dwelling problems	0.013***	0.022***	0.032***
	(5.153)	(6.954)	(10.231)
Heating problems	0.012***	0.006	0.013**
	(3.470)	(1.512)	(3.197)
No bath/shower	0.004	0.001	0.002
	(0.338)	(0.060)	(0.185)
No toilet for sole use	0.011	−0.008	0.008
	(0.990)	(−0.698)	(0.662)
Tenure status, ref. category: owner			
Tenant market rate	−0.006	−0.018	−0.016
	(−0.741)	(−1.561)	(−1.420)
Tenant reduced rate	0.017	0.004	0.019
	(1.951)	(0.296)	(1.531)
Free accommodation	0.006	0.005	0.018*
	(0.850)	(0.603)	(1.976)
Education, ref. category: pre-primary education			
Primary education	0.042	−0.036	−0.051
	(0.988)	(−0.716)	(−1.173)
Low sec. education	0.047	−0.037	−0.047
	(1.084)	(−0.734)	(−1.067)
Upper sec. education	0.047	−0.037	−0.042
	(1.088)	(−0.733)	(−0.955)

Continued on next page...

... table 10 continued

	SAH	ADL	Chronic
Post-sec. non-tert. education	0.055	−0.030	−0.039
	(1.266)	(−0.585)	(−0.877)
Tertiary education	0.047	−0.038	−0.036
	(1.099)	(−0.738)	(−0.801)
Income poverty			
Income poverty	0.001	0.001	−0.001
	(0.484)	(0.184)	(−0.327)
Age			
Age	−0.005**	−0.015***	−0.008**
	(−2.692)	(−5.497)	(−2.982)
Age squared	0.000**	0.000***	0.000***
	(2.730)	(7.103)	(7.147)
Marital status, ref. category: single			
Married	−0.003	−0.003	−0.018*
	(−0.513)	(−0.295)	(−1.963)
Separated	0.009	−0.019	−0.005
	(0.766)	(−1.182)	(−0.326)
Widowed	0.026*	0.027	0.005
	(2.407)	(1.930)	(0.382)
Divorced	0.007	0.007	0.000
	(0.799)	(0.595)	(0.023)
Current economic status, ref. category: full-time work			
Part-time work	−0.000	−0.008	−0.010
	(−0.087)	(−1.364)	(−1.746)
Unemployed	−0.001	−0.002	0.001
	(−0.147)	(−0.423)	(0.218)
Pupil, student, further training	−0.006	−0.008	0.000
	(−1.904)	(−1.304)	(0.073)
(Early) retirement	−0.018**	−0.013	0.002
	(−2.905)	(−1.666)	(0.215)
Unable/unfit to work	−0.027**	−0.010	−0.002
	(−2.726)	(−1.004)	(−0.257)
Military or community service	−0.011	−0.030	−0.015
	(−0.731)	(−1.435)	(−0.666)
Domestic tasks or care	0.002	−0.009	−0.014
	(0.467)	(−1.233)	(−1.924)
Other inactive person	−0.014*	−0.008	−0.004
	(−2.027)	(−0.990)	(−0.507)
Constant	0.172**	0.448***	0.189*
	(3.068)	(5.576)	(2.461)
N	355565	355565	355565
adj. R^2	0.001	0.001	0.003

t statistics in parentheses; Standard errors clustered at the household level

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

Table 11: Equivalized disposable income

	SAH	ADL	Chronic
Housing deprivation			
Overcrowding	−0.005	0.004	0.004
	(−1.610)	(1.085)	(0.965)
Dwelling problems	0.013***	0.022***	0.032***
	(5.152)	(6.954)	(10.232)
Heating problems	0.012***	0.006	0.013**
	(3.470)	(1.512)	(3.197)
No bath/shower	0.004	0.001	0.002
	(0.339)	(0.057)	(0.182)
No toilet for sole use	0.011	−0.008	0.008
	(0.987)	(−0.699)	(0.664)
Tenure status, ref. category: owner			
Tenant market rate	−0.006	−0.018	−0.016
	(−0.744)	(−1.561)	(−1.418)
Tenant reduced rate	0.017	0.004	0.019
	(1.951)	(0.299)	(1.532)
Free accommodation	0.006	0.005	0.018*
	(0.851)	(0.609)	(1.977)
Education, ref. category: pre-primary education			
Primary education	0.042	−0.036	−0.051
	(0.989)	(−0.714)	(−1.173)
Low sec. education	0.047	−0.037	−0.047
	(1.084)	(−0.732)	(−1.066)
Upper sec. education	0.047	−0.037	−0.042
	(1.089)	(−0.731)	(−0.955)
Post-sec. non-tert. education	0.055	−0.030	−0.039
	(1.267)	(−0.582)	(−0.876)
Tertiary education	0.048	−0.038	−0.036
	(1.100)	(−0.736)	(−0.801)
Income			
Equivalized disposable income	0.000	0.001	0.000
	(0.144)	(0.710)	(0.183)
Age			
Age	−0.005**	−0.015***	−0.008**
	(−2.713)	(−5.531)	(−2.980)
Age squared	0.000**	0.000***	0.000***
	(2.745)	(7.133)	(7.148)
Marital status, ref. category: single			
Married	−0.003	−0.003	−0.018*
	(−0.510)	(−0.295)	(−1.965)
Separated	0.009	−0.019	−0.005
	(0.766)	(−1.183)	(−0.327)
Widowed	0.026*	0.027	0.005
	(2.413)	(1.939)	(0.380)
Divorced	0.007	0.007	0.000
	(0.802)	(0.600)	(0.022)
Current economic status, ref. category: full-time work			
Part-time work	−0.000	−0.007	−0.010
	(−0.079)	(−1.346)	(−1.744)

Continued on next page...

... table 11 continued

	SAH	ADL	Chronic
Unemployed	−0.000	−0.002	0.001
	(−0.120)	(−0.380)	(0.215)
Pupil, student, further training	−0.006	−0.007	0.000
	(−1.868)	(−1.258)	(0.073)
(Early) retirement	−0.018**	−0.013	0.002
	(−2.895)	(−1.636)	(0.218)
Unable/unfit to work	−0.027**	−0.009	−0.002
	(−2.718)	(−0.978)	(−0.254)
Military or community service	−0.011	−0.030	−0.015
	(−0.726)	(−1.425)	(−0.666)
Domestic tasks or care	0.002	−0.008	−0.014
	(0.493)	(−1.189)	(−1.924)
Other inactive person	−0.014*	−0.008	−0.004
	(−2.010)	(−0.954)	(−0.507)
Constant	0.173**	0.447***	0.188*
	(3.086)	(5.568)	(2.446)
N	355565	355565	355565
adj. R^2	0.001	0.001	0.003

t statistics in parentheses; Standard errors clustered at the household level
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 12: Results logistic regression (logOdds displayed)

	SAH	ADL	Chronic
Housing deprivation			
Overcrowding	−0.077	0.044	0.033
	(−1.567)	(1.157)	(0.865)
Dwelling problems	0.218***	0.234***	0.361***
	(5.370)	(7.383)	(10.943)
Heating problems	0.167***	0.067	0.146***
	(3.589)	(1.697)	(3.591)
No bath/shower	0.042	0.021	0.024
	(0.294)	(0.154)	(0.185)
No toilet for sole use	0.120	−0.116	0.050
	(0.819)	(−0.868)	(0.387)
Tenure status, ref. category: owner			
Tenant market rate	−0.137	−0.208	−0.184
	(−0.729)	(−1.550)	(−1.372)
Tenant reduced rate	0.360	0.038	0.195
	(1.901)	(0.266)	(1.384)
Free accommodation	0.115	0.045	0.195*
	(1.055)	(0.516)	(2.195)
Education, ref. category: pre-primary education			
Primary education	0.461	−0.297	−0.482
	(1.033)	(−0.802)	(−1.149)
Low sec. education	0.517	−0.315	−0.392
	(1.145)	(−0.845)	(−0.926)

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... table 12 continued

	SAH	ADL	Chronic
Upper sec. education	0.473	−0.340	−0.346
	(1.028)	(−0.899)	(−0.809)
Post-sec. non-tert. education	0.728	−0.252	−0.305
	(1.498)	(−0.646)	(−0.697)
Tertiary education	0.464	−0.356	−0.245
	(0.951)	(−0.915)	(−0.561)
Income			
Disposable income	−0.000	0.000	−0.000
	(−0.230)	(0.334)	(−0.792)
Age			
Age	−0.167*	−0.171***	0.001
	(−2.453)	(−4.209)	(0.036)
Age squared	0.002**	0.002***	0.001***
	(2.817)	(6.064)	(3.831)
Marital status, ref. category: single			
Married	−0.094	−0.046	−0.277*
	(−0.516)	(−0.374)	(−2.134)
Separated	0.140	−0.237	−0.090
	(0.584)	(−1.287)	(−0.476)
Widowed	0.273	0.212	−0.003
	(1.481)	(1.513)	(−0.022)
Divorced	0.073	0.049	−0.038
	(0.399)	(0.361)	(−0.277)
Current economic status, ref. category: full-time work			
Part-time work	−0.003	−0.097	−0.117
	(−0.032)	(−1.375)	(−1.672)
Unemployed	−0.018	−0.028	0.003
	(−0.186)	(−0.424)	(0.050)
Pupil, student, further training	−0.262	−0.089	0.061
	(−0.925)	(−0.667)	(0.486)
(Early) retirement	−0.242*	−0.141	−0.024
	(−2.449)	(−1.847)	(−0.317)
Unable/unfit to work	−0.261**	−0.102	−0.050
	(−2.633)	(−1.069)	(−0.475)
Military or community service	−0.397	−0.683	−0.430
	(−0.579)	(−1.313)	(−0.810)
Domestic tasks or care	0.052	−0.111	−0.166
	(0.408)	(−1.263)	(−1.907)
Other inactive person	−0.214	−0.099	−0.070
	(−1.695)	(−0.987)	(−0.690)
N	25315	46362	45743
Log lik.	$-9.0e+03$	$-1.7e+04$	$-1.6e+04$

t statistics in parentheses

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

Table 13: Cutoff

	Stronger SAH	Weaker SAH	Stronger ADL
Housing deprivation			
Overcrowding	−0.003	−0.008	−0.001
	(−1.703)	(−1.938)	(−0.295)
Dwelling problems	0.006***	0.016***	0.007**
	(4.303)	(5.074)	(3.145)
Heating problems	0.004	0.020***	0.013***
	(1.934)	(4.950)	(4.482)
No bath/shower	0.000	−0.008	0.001
	(0.047)	(−0.579)	(0.100)
No toilet for sole use	0.004	0.007	−0.006
	(0.511)	(0.530)	(−0.644)
Tenure status, ref. category: owner			
Tenant market rate	0.001	−0.008	−0.005
	(0.333)	(−0.649)	(−0.670)
Tenant reduced rate	−0.003	0.018	0.016*
	(−0.526)	(1.366)	(1.980)
Free accommodation	−0.003	−0.004	0.000
	(−0.634)	(−0.507)	(0.050)
Education, ref. category: pre-primary education			
Primary education	−0.014	0.025	−0.020
	(−0.551)	(0.522)	(−0.543)
Low sec. education	−0.019	0.023	−0.016
	(−0.781)	(0.489)	(−0.427)
Upper sec. education	−0.014	0.025	−0.009
	(−0.582)	(0.531)	(−0.252)
Post-sec. non-tert. education	−0.013	0.033	−0.008
	(−0.513)	(0.688)	(−0.224)
Tertiary education	−0.012	0.033	−0.007
	(−0.505)	(0.684)	(−0.189)
Income			
Disposable income	−0.000	0.000	0.000
	(−1.050)	(0.809)	(0.231)
Age			
Age	−0.007***	−0.013***	−0.009***
	(−7.031)	(−4.925)	(−5.001)
Age squared	0.000***	0.000***	0.000***
	(7.179)	(3.561)	(4.228)
Marital status, ref. category: single			
Married	−0.001	0.004	−0.009
	(−0.158)	(0.425)	(−1.490)
Separated	0.006	−0.025	−0.002
	(0.858)	(−1.471)	(−0.176)
Widowed	0.008	0.021	−0.000
	(1.114)	(1.589)	(−0.045)
Divorced	0.011*	0.005	−0.001
	(2.098)	(0.431)	(−0.125)
Current economic status, ref. category: full-time work			
Part-time work	−0.003*	−0.004	−0.001
	(−2.020)	(−0.642)	(−0.328)

Continued on next page...

... table 13 continued

	Stronger SAH	Weaker SAH	Stronger ADL
Unemployed	−0.003	0.011	−0.006
	(−1.611)	(1.932)	(−1.786)
Pupil, student, further training	−0.005**	−0.011	−0.012***
	(−2.730)	(−1.781)	(−3.728)
(Early) retirement	−0.009*	−0.009	−0.005
	(−2.569)	(−1.116)	(−0.788)
Unable/unfit to work	−0.006	−0.017*	−0.039***
	(−0.851)	(−2.029)	(−3.956)
Military or community service	−0.004**	−0.028	−0.039*
	(−3.139)	(−1.603)	(−2.538)
Domestic tasks or care	−0.002	−0.011	−0.000
	(−0.583)	(−1.438)	(−0.035)
Other inactive person	−0.002	−0.002	−0.019**
	(−0.620)	(−0.236)	(−2.962)
Constant	0.150***	0.751***	0.291***
	(4.873)	(9.090)	(5.666)
N	355565	355565	355565
adj. R^2	0.001	0.001	0.001

t statistics in parentheses; Standard errors clustered at the household level
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 14: Results without Bulgaria, Poland, Portugal and Romania

	SAH	ADL	Chronic
Housing deprivation			
Overcrowding	−0.006	0.006	0.004
	(−1.809)	(1.324)	(0.886)
Dwelling problems	0.013***	0.016***	0.032***
	(4.724)	(4.566)	(9.416)
Heating problems	0.021***	0.015**	0.021***
	(5.225)	(3.035)	(4.356)
No bath/shower	−0.007	0.004	0.002
	(−0.487)	(0.212)	(0.135)
No toilet for sole use	−0.004	−0.021	0.010
	(−0.288)	(−1.297)	(0.612)
Tenure status, ref. category: owner			
Tenant market rate	−0.009	−0.033**	−0.024*
	(−1.078)	(−2.701)	(−1.974)
Tenant reduced rate	0.014	−0.007	0.011
	(1.563)	(−0.550)	(0.839)
Free accommodation	0.007	0.009	0.023
	(0.685)	(0.809)	(1.927)
Education, ref. category: pre-primary education			
Primary education	0.064	−0.014	−0.027
	(1.398)	(−0.248)	(−0.610)
Low sec. education	0.068	−0.015	−0.024
	(1.494)	(−0.270)	(−0.545)

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... table 14 continued

	SAH	ADL	Chronic
Upper sec. education	0.068	−0.014	−0.016
	(1.490)	(−0.253)	(−0.366)
Post-sec. non-tert. education	0.077	−0.008	−0.016
	(1.670)	(−0.140)	(−0.350)
Tertiary education	0.068	−0.015	−0.013
	(1.485)	(−0.262)	(−0.287)
Income			
Disposable income	−0.000	0.000	−0.000
	(−0.321)	(0.544)	(−1.056)
Age			
Age	−0.004*	−0.011***	−0.008*
	(−2.071)	(−3.787)	(−2.538)
Age squared	0.000*	0.000***	0.000***
	(2.123)	(4.452)	(7.268)
Marital status, ref. category: single			
Married	−0.004	−0.003	−0.024*
	(−0.580)	(−0.291)	(−2.367)
Separated	0.007	−0.019	0.001
	(0.552)	(−1.056)	(0.059)
Widowed	0.023	0.022	0.009
	(1.960)	(1.459)	(0.640)
Divorced	0.006	0.006	0.003
	(0.598)	(0.485)	(0.209)
Current economic status, ref. category: full-time work			
Part-time work	0.002	−0.003	−0.008
	(0.464)	(−0.540)	(−1.293)
Unemployed	−0.003	−0.002	−0.003
	(−0.681)	(−0.266)	(−0.499)
Pupil, student, further training	−0.007*	−0.008	−0.000
	(−1.999)	(−1.119)	(−0.011)
(Early) retirement	−0.017*	−0.012	0.006
	(−2.506)	(−1.315)	(0.627)
Unable/unfit to work	−0.034**	−0.005	−0.006
	(−2.905)	(−0.499)	(−0.559)
Military or community service	−0.012	−0.031	−0.016
	(−0.752)	(−1.405)	(−0.689)
Domestic tasks or care	0.002	−0.010	−0.014
	(0.429)	(−1.242)	(−1.752)
Other inactive person	−0.009	−0.012	−0.005
	(−1.104)	(−1.164)	(−0.473)
Constant	0.131*	0.441***	0.077
	(2.185)	(4.840)	(0.912)
N	284949	284949	284949
adj. R^2	0.001	0.001	0.004

t statistics in parentheses; Standard errors clustered at the household level

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

Table 15: Influence of health on moving probability

	Move	Move	Move
Health indicator			
SAH	−0.000		
	(−0.061)		
ADL		−0.001	
		(−1.633)	
Chronic			0.002*
			(2.541)
Tenure status, ref. category: owner			
Tenant market rate	−0.063***	−0.062***	−0.063***
	(−6.553)	(−6.455)	(−6.505)
Tenant reduced rate	−0.050***	−0.049***	−0.049***
	(−5.511)	(−5.382)	(−5.361)
Free accommodation	−0.013**	−0.013**	−0.013**
	(−2.990)	(−2.896)	(−2.967)
Education, ref. category: pre-primary education			
Primary education	0.006	0.006	0.006
	(0.804)	(0.846)	(0.827)
Low sec. education	0.004	0.005	0.004
	(0.572)	(0.615)	(0.545)
Upper sec. education	0.003	0.003	0.003
	(0.373)	(0.367)	(0.325)
Post-sec. non-tert. education	0.000	0.000	−0.000
	(0.011)	(0.005)	(−0.054)
Tertiary education	−0.003	−0.003	−0.004
	(−0.383)	(−0.392)	(−0.451)
Income			
Disposable income	0.000	0.000	0.000
	(0.768)	(0.609)	(0.686)
Age			
Age	0.048***	0.048***	0.048***
	(38.557)	(38.522)	(38.662)
Age squared	−0.000***	−0.000***	−0.000***
	(−26.892)	(−26.751)	(−26.964)
Marital status, ref. category: single			
Married	0.030***	0.029***	0.029***
	(5.052)	(5.041)	(5.064)
Separated	0.024**	0.024**	0.024**
	(2.864)	(2.910)	(2.913)
Widowed	0.028***	0.028***	0.028***
	(4.584)	(4.555)	(4.550)
Divorced	0.032***	0.031***	0.031***
	(5.278)	(5.201)	(5.188)
Current economic status, ref. category: full-time work			
Part-time work	0.001	0.001	0.001
	(0.649)	(0.608)	(0.677)
Unemployed	−0.001	−0.001	−0.001
	(−0.611)	(−0.754)	(−0.577)
Pupil, student, further training	−0.006	−0.007	−0.007
	(−1.733)	(−1.940)	(−1.849)

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... table 15 continued

	Move	Move	Move
(Early) retirement	−0.000	−0.001	−0.001
	(−0.235)	(−0.307)	(−0.397)
Unable/unfit to work	0.001	0.001	0.001
	(0.292)	(0.233)	(0.245)
Military or community service	−0.005	0.005	0.006
	(−0.330)	(0.357)	(0.379)
Domestic tasks or care	−0.003	−0.003	−0.003
	(−1.301)	(−1.352)	(−1.302)
Other inactive person	−0.001	−0.001	−0.001
	(−0.334)	(−0.360)	(−0.214)
Constant	−1.511***	−1.502***	−1.507***
	(−44.262)	(−44.252)	(−44.359)
N	431089	432540	432371
adj. R^2	0.037	0.037	0.037

t statistics in parentheses; Standard errors clustered at the household level

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