On the Economics of Health in Homes

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Abstract

The effects of outdoor climate and air pollution on health outcomes have been well documented, but in developed countries, individuals spend most of their time indoors, particularly in their own home. This paper investigates the relationship between indoor housing conditions and occupant health, using a detailed longitudinal dataset of some 25,000 German households. The analysis shows that individuals living in poorly-maintained homes tend to report a higher number of health issues, after controlling for socio-economic status and health-affecting lifestyle choices. Those individuals also experience a 12-percent increase in their demand for healthcare, as reflected in the number of visits to the doctor. We document significant heterogeneity in the detrimental effect of poor housing quality on the demand for health care – the effects are strongest for women, who visit their doctor up to 22 percent more often if they live in poorly maintained homes. For age groups over 51 years, occupants of homes needing a major renovation visit the doctor about 30 percent more often as compared to those living in homes with a good condition. The results have some implications for policymakers, who are increasingly seeking for prevention of disease as means to reduce the burden of rapidly increasing healthcare costs.

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1 Introduction

Increasing welfare and longevity, and the corresponding rise in the demand for health services, are confronting society with ever-rising healthcare costs. Projections of these costs for 2060 are as high as 10.3 percent of U.S. GDP and 9.7 percent of E.U. GDP (Maisonneuve and Martins, 2013). Understanding the causes of health deprivation, and providing solutions towards prevention it presents an increasingly critical challenge for academia, private market participants, and policymakers.

Environmental characteristics have long been shown to affect health, with most research focusing on the outdoor environment, studying the effects of temperature, and air and water pollution. The impact of environmental issues on welfare-relevant factors, such as human capital formation, productivity and health has been well established in the literature. For example, there is growing evidence on causal links between environmental hazards such as extreme temperatures and air pollution (Deschênes and Greenstone, 2011) and human health. In particular, the literature documents significant effects of air pollution on infant mortality rates (Currie and Neidell, 2005; Luechinger, 2009), (low) birth weights (Currie et al., 2015), school absence (Currie et al., 2009), hours of sick leave (Hanna and Oliva, 2015), and respiratory and heart-related hospital admissions (Schlenker and Walker, 2016).

However, existing studies solely rely on outdoor measurements, assessing the exposure to the environmental hazards based on weather or air quality stations in cities, whereas 90 percent of an individual's time is typically spent indoors. People are working in office buildings, living in single-family or apartment buildings, and spending leisure time in shopping malls or restaurants (Klepeis et al., 2001). Of the time spent indoors, most is spent in at home.

This is where the main contribution of our study lies, exploring the direct impact of indoor housing conditions on the health status of private individuals and their demand for health care, using a sample of some 24,849 German households.

Our understanding regarding the relationship between the indoor environment and health mostly comes from the engineering and health science literature. But the existing studies on the relationship between dwelling conditions and occupant health have two

main shortcomings. They are typically hard to generalize, or they do not firmly establish causality. There are a number of high-quality, small-scale intervention studies providing evidence on the link between specific hazards in the indoor environment (e.g. mold) and certain illness (e.g. respiratory diseases). [1] Evidence from larger studies based on interventions in developing countries shows the health benefits of housing interventions such as cementing floors (Cattaneo et al., 2009) or replacing cooking stoves (Hanna et al., 2016), and point to an increase in the quality of life and health as a result of such major changes in the indoor environment. However, such interventions are hardly applicable to the building stock in most OECD countries, making it difficult to generalize the results to Western economies. At the same time, the studies covering developed countries rely mostly on cross-sectional surveys (WHO, 2007) , which can only show correlation, not causation.

As opposed to relying on small-scale intervention studies or cross-sectional surveys, this study takes a different approach to explore the direct impact housing conditions on the demand for health care. The starting point is that household panel datasets and transparent statistical models can complement evidence from the experiment-based medical literature, helping to generalize its results. In order to examine the link between housing conditions and health, we exploit the German Socio Economic Panel. This dataset is, to the best of our knowledge, the longest individual-level dataset, collecting information on both health and housing conditions annually since 1984 (Wagner et al., 2007). Each year, individuals are asked to evaluate the conditions of their dwelling and to complete an extensive questionnaire on subjective health status (i.e., the SF-12 questionnaire), and on their demand for health care, objectively measured by the number of visits to the doctor and the days of sick leave.

This paper's conceptual framework is derived from the classical health production model developed by Becker and Grossman (Grossman, 2000). Specifically, we estimate the impact of poor housing conditions on subjective health measures and demand for health care. The documented effects are substantial – those individuals living in dwellings with a poor indoor environment experience a 12 percent increase in their demand for health care, as reflected

[1] See Thomson et al. (2009) for an extensive survey of such intervention studies.

in the number of visits to the doctor. These citizens are not more likely to visit to the doctor in the first place, but once they go, they go more often. The effects show substantial heterogeneity based on dwelling conditions, and hold across income groups. We also show that the detrimental effect of poor housing quality on health is much higher for women than it is for men. Moreover, the effects of poor housing conditions on medical service consumption increases with age. Results from our analysis of subjective health measures suggest that the increase in demand for health care is mainly driven by a deterioration of mental health. Interestingly, we do not find a statistically significant relationship between poor housing conditions and days of sick leave from work. Our results are robust to a variety of specifications and a range of robustness checks.

In the remainder of this paper, we first describe the existing literature assessing the impact of housing conditions on individuals' health. In section 3, we describe the data sources and provide some descriptive statistics. In section 4, we briefly present the methods employed, and specifically discuss issues of causality and identification. In section 5, the results of the empirical analysis are provided. The paper ends with conclusions and policy implications.

2 Literature

Economists often approach health with the theoretical model of Grossman (1972), where individuals are born with a stock of capital that depreciates over the years and increases through different investments, such as sports. An adult's health is the main determinant of the number of days that an individual is productive in the labor market and, in turn, able to work and to earn income. Over the past decades, scholars have made a persistent effort on the identification of different factors affecting the rate of health depreciation and the demand for health investments.

The literature on health and environmental economics has documented the link between different aspects of individuals' living conditions and their health status. In the socioeconomic domain, studies using self-reported health indicators from different countries such as the US, the UK, or Germany show a direct relation between household income and the

health conditions of individuals (Adams et al., 2003; Contoyannis et al., 2004; Frijters et al., 2005).

Long-term evidence from the often-cited field experiment "Moving to Opportunity" shows that participants who moved from low income neighborhoods to less distressed areas subsequently had measurably improved physical and mental health and well-being (Ludwig et al., 2012).

The impact of the living environment on individuals' health is not limited to socio-economic channels. The literature in environmental economics has shown the detrimental effects of different environmental hazards on health outcomes. In particular, a number of studies document the relation between high levels of air pollutants (e.g. ozone or carbon monoxide) and increases in respiratory and heart-related emergency room admissions (Schlenker and Walker, 2016), low birth weight (Currie et al., 2015), and higher school absences (Currie et al., 2009).

The existing studies regarding the exposure of individuals to environmental hazards commonly rely on outdoor measurements (e.g. Currie et al., 2015; Currie, 2009; Deschênes and Greenstone, 2011). However, while the indoor conditions of homes are a function of outdoor conditions in the surroundings of the dwelling, they are not fully determined by outdoor conditions alone. Individuals can take multiple actions against outdoor environmental hazards to mitigate their exposure. One of the most common examples is to adjust the heating or cooling to avoid exposure to extreme temperatures. Deschênes and Greenstone (2011) document the presence of avoidance behavior under extreme temperatures in the U.S. between 1968 and 2002; where extreme outdoor temperatures systematically preceded peaks in both mortality rates and energy consumption. Thus, individuals seem to be able to isolate themselves from outside environmental hazards or at least to reduce their exposure dramatically. Although we spend 90 percent of our time indoors, not much is known about the impact of buildings on health outcomes. The existing knowledge on the impact of the indoor environment on health comes mostly from the medical literature and is based on small-scale experiments or cross-sectional surveys. An example is a pan-European housing and health survey that involves inspections of dwellings by trained surveyors (WHO, 2007). The results suggest that people living in homes with poor condi-

tions (e.g. bad lighting and ventilation, much noise, etc.) systematically reported a higher number of mental and respiratory health problems. However, these results are solely based on cross-sectional analysis and therefore do not shed much light on causal effects.

Intervention studies allow researchers to isolate biological impacts, but generalization of their results tends to be limited by small sample sizes and the characteristics of the participants. Indeed, after reviewing the medical intervention studies published between 1887 and 2007 in different Western countries, Thomson et al. (2009) address the need for large-sample studies using micro data, to better estimate dose-response functions and the potential for house improvements.

A third strand of literature based on quasi-experimental studies involves policy interventions in slums or developing countries, where socio-demographic characteristics differ quite fundamentally from those of the average households, in the United States or European Union countries. An example of this type of studies was carried out in Mexico where the authors explored the effect of replacing dirt floors with cement flooring. This intervention produced significant improvements in occupants' health, measured by reductions in the number of respiratory problems and allergies (Cattaneo et al., 2009). However, it remains an open question whether dwelling conditions also have such significant health effects when the baseline quality is already quite satisfactory, as will likely be the case in richer countries.

3 Data and Descriptive Statistics

In order to identify the relationship between housing conditions and health outcomes, we benefit from a large longitudinal dataset containing information on both house conditions and occupant health status, as well as other household characteristics likely to affect health outcomes. The German Socio-Economic Panel (SOEP, v31) provides the longest person-level dataset, with yearly information on health and house conditions since 1984, covering more than 20,000 individuals and 11,000 households (Wagner et al., 2007). The longitudinal nature of the dataset enables us to control for unobserved individual characteristics, by focusing on the relationship between the over-time variation in housing conditions and

health situation of individuals. In addition, the survey includes extensive information on socio-economic and demographic characteristics of individuals, their health status, as well as detailed information about living conditions.

We use the data from all available waves for West Germany after re-unification, covering the period from 1992 through 2014.[2] The full sample includes 57,581 adults (30,151 women and 27,430 men) in a total of 24,849 households. The average duration that an individual is included in the survey is 6.48 years (std. dev. = 5.27), with a maximum of 23 years.

3.1 Health outcomes

The SOEP provides information on several health metrics. In this paper, we focus on three different health outcomes to establish the link between house conditions and health: (1) health status, (2) healthcare utilization and (3) health behavior.

With respect to health status, we use the Mental and Physical Component Summary Scales. These measures are constructed based on the answers of participants to the health SF-12 questionnaire. The questionnaire is included in the SOEP every two years since 2002, and contains 12 different questions about the mental and the physical health status of respondents in the four weeks preceding the interview (e.g. "How often did you have strong physical pains in the last four weeks?"). The mental and physical scales are constructed based on factor analysis, ranging from 0 to 100 (with higher values denoting better a health status).[3] These scales are widely used in the economic literature to explore detrimental effect of different hazardous events (e.g. Eibich, 2015; Marcus, 2013; Schiele and Schmitz, 2016).

In addition to mental and physical health, we also include individuals' self-assessed health status over the last year (on a five-point Likert scale). [4] Self-assessed health measures are commonly used in empirical studies to explore the dynamics of health in a given

[2]While the SOEP starts in 1984, the current health status is not incorporated until the beginning of our sample period.

[3]A detailed description about the construction of the scales is provided by Andersen et al. (2007).

[4]Every year, participants are asked to assess their "current health" as: "very good", "good", "satisfactory", "poor" or "bad."

population of interest (Contoyannis et al., 2004), or to estimate the damaging effect of different aspects of living conditions (Bilger and Carrieri, 2013; Frijters et al., 2005).

We use the number of visits to the doctor as a measure of healthcare utilization. Participants are asked to report the number of times they visited their general practitioner in the last three months. This measure is widely used in the literature to explore the increase in demand for health care. We explore the effect of housing conditions on health care utilization based on two measures: (1) the likelihood of going at least once to the doctor in the last months, and (2) on the number of doctor visits in the last three months. We also look at the days of sick leave reported over the last three months.

Finally, we use the body mass index as a measure of health behavior. Good health behavior refers to the different activities undertaken by individuals to sponsor their health status or preventing illnesses. Typical examples are sports, (quitting) smoking, or (healthy) nutrition. In the literature of health economics, body mass index is typically used to capture the effect of good health behavior on health status (Künn-Nelen, 2016; Reinhold and Jürges, 2010).

3.2 House conditions

We evaluate the condition of participants' dwellings based on the self-assessment of dwelling conditions. Each year, all survey participant are asked the following question: "How would you characterize the condition of the house in which you live? Is it in good condition, in need of partial renovation, or in need of complete renovation?". Based on the answer given to this question, we categorized each dwelling in the sample as (1) in good condition, (2) in need of minor renovation or (3) in need of full renovation.[5] Out of the 56,459 participants for whom the information on housing conditions is available, 28,635 lived at least one year in a house in need of minor renovations, and 4,856 lived at least one year in a home in need of major renovations.

[5]In the original question in the GSOEP, respondents have an additional option: "Ready for demolition". However, given the low number of responses in that category we decided to omit this option in the analysis, and these observations are removed from the sample.

3.3 Demographic characteristics

In the analysis, we also control for the following socio-demographic characteristics: age, household composition, household income, marital status, labor force status (whether the individual is working or not, and whether there is a significant change in his/her occupational status in the year of the survey), education (based on number of years of education and whether the individual holds a college degree), gender, ratio of household members to number of rooms in the house. These variables are commonly used in the literature as determinants of health outcomes, sick leave, and demand for health care (e.g. Adams et al., 2003; Contoyannis et al., 2004; Currie et al., 2009).

3.4 Descriptive statistics

Table 1 provides summary statistics. The average scales on mental and physical health are very close to 50, out of a maximum scale of 100, and the average current health status is 2.57, on a scale of 1 to 5. Of all participants, 25 percent report bad health. Participants have an average of 5.5 days of sick leave per year and report an average of 2.6 doctor visits in the three months preceding the survey.

[Table 1 about here.]

Regarding dwelling conditions, 71 percent of participants report that their home is in good condition, while 27 and 2 percent report the need for a partial or major renovation, respectively.

We compare average health outcomes based on different housing condition categories using some simple visualizations. As illustrated in Figure 1, individuals living in homes in need of partial or full renovation systematically and significantly report poorer health status, no matter which health criterion we consider. The detrimental effect of poor housing conditions is also reflected in the physical and mental scales, as those individuals living in poor housing conditions report significantly lower values on the physical indicators and especially in their mental scale. Last, individuals in poorly maintained houses report significantly higher number of visits to the doctor in the three months preceding the date of

the survey: about 2.5 visits for those living in dwellings in good condition, compared to more than three visits for those living in a home that needs a full renovation.

Of course, these non-parametric comparisons do not take into account the fact that not every participant in the sample has the same probability of experiencing poor housing conditions. Table 2 shows systematic differences between individuals living in good housing conditions and those inhabiting homes in need of partial or full renovation. Participants living in homes with deficiencies report lower levels of income, are younger, and are more likely to be tenants rather than owners. Moreover, dwellings with deficiencies are typically smaller, older, and have considerably lower values and rents than homes in good condition. They are also more likely to be apartments.

[Table 2 about here.]

Thus, the relationship between health and housing conditions could be merely driven by socio-economic factors that determine both dwelling choice and health, which would affect our inferences regarding the link between housing conditions and health. In particular, previous empirical studies show that income is one of the main factors shaping the demand for health services (e.g. Frijters et al., 2005). Furthermore, those individuals with larger financial means are expected to accommodate better homes, so the apparent relationship documented in the figures above might be driven by differences in socioeconomic status. Other potential confounding variables are occupant age and tenure status. Poorer people are more likely to live in rental housing, which tends to be less well maintained than owner-occupied housing (Pollack et al., 2004).

To provide further insights on this, Table 3 shows the relation between health and housing conditions for different income and age groups, by quartile, and for owner-occupiers and tenants. Panels A through E provide the numbers for the five different health indicators we employ: bad health status, mental health scale, physical health scale, doctor visits, and days of sick leave. As expected, these statistics indicate that higher income, lower age, and home ownership are all associated with better health. However, the descriptive statistics also show that the detrimental health effect of poor housing conditions holds for almost any age or income group in the sample, and likewise for home-owners and tenants, no

matter how we measure health. Interestingly, the statistics reported in Table 3 suggest that the relationship between poor housing quality and health status is stronger for older and lower-income respondents as compare to higher-paid and younger people.

[Table 3 about here.]

4 Empirical Strategy

A proper analysis of the impact of housing conditions on occupant health requires taking into account the role of different socio-economic characteristics of individuals. Investment decisions in health and individual preferences for dwelling are driven by a complex set of (observable and unobservable) household and individual characteristics. Furthermore, both are likely to be driven by some common factors, possibly polluting the estimated effect of house conditions on health.

In order to identify the impact of housing conditions on individual's health, we propose the following reduced-form empirical model:

$$Health^{*}_{i,d,t} = \beta HousingConditions_{d,t} + \lambda X_{i,t} + \delta Z_{d,t} + \alpha_i + t_t + \epsilon_{i,d,t} \tag{1}$$

where $Health^{*}_{i,d,t}$ denotes the health status of individual i, living in dwelling d, in year t. The health status of individuals will be measured by the health outcomes described in the previous section. $Housing \quad conditions_{d,t}$ represents the conditions of the dwelling d at time t. The vector $Housing \quad conditions_{d,t}$ includes two dummy variables, one of them taking the value of one if the dwelling needs a partial renovation, and zero otherwise, and the other dummy taking the value of one if the dwelling is in need of a full renovation, and zero otherwise. The vector $X_{i,t}$ and $Z_{d,t}$ nclude all the individual and house control variables, respectively. The unobserved components of the model includes the time-invariant idiosyncratic effects, α_i, time (year) fixed effects, t_t, and the normally distributed error term, $\epsilon_{i,d,t}$. Based on this model, the parameters of interest, elements of β, represents the effect of dwelling conditions on the health status of individuals.

As stated above, estimating the causal link between dwelling conditions and occupant health is methodologically challenging. The literature acknowledges the existence of multi-

ple confounders, or variables affecting both the preferences of an individual for the dwelling and the investments in health. The presence of multiple behavioral factors common in both dwelling selection and health decisions precludes the inclusion of all the necessary controls in a regression analysis. The presence of such unobserved factors hinders the proper estimation of the link between dwelling conditions and health from the cross-sectional analysis. In the following sections, we make use of the longitudinal nature of our data set to alleviate concerns about potential endogeneity issues.

The over-time variation in the data allows for the estimation of fixed effects (FE) models in which the unobserved characteristics of individuals can be properly controlled for. This approach employs the variation in house conditions and health over time for each individual, reducing concerns about self-selection of unhealthy individuals into low-quality homes. Thus, the effect of poor housing conditions on occupant health is identified by the variation in housing conditions over years within observations for the same individual.

The over-time variation in housing conditions can originate from either moving to a new house or from a change in the conditions of the existing dwelling. It is well established in the literature that the environmental and socio-economic conditions of the neighborhood affect human health through channels like crime or pollution (Bilger and Carrieri, 2013; Ludwig et al., 2012). In order to isolate the effect of housing from neighborhood-related effects, we also estimate the FE model excluding movers from the sample. Thus, we can ensure that the changes in living conditions originate from changes in existing housing conditions, and not changes in the neighborhood.

As a final check on the role of potential confounders that may simultaneously affect housing choice and health outcomes, we employ the body mass index of the respondents. The body mass index is widely used as an indicator of health investments by individuals (e.g. Künn-Nelen, 2016; Reinhold and Jürges, 2010), and we test whether it is related to housing conditions. If not, we can safely conclude that the role of confounding effects is limited, providing more confidence in the causal relationship between housing conditions and health outcomes.

5 Results

5.1 Effects of dwelling conditions on health status

We first estimate the model specified in equation (1) using pooled OLS to investigate whether housing conditions affect subjective health status, using as dependent variable the "bad health" perception indicator, the mental health scale, and the physical health scale. The OLS estimation results are reported in Table 4, columns 1, 3, and 5. For each of the three health indicators, we document that individuals living in homes in need of renovation report significantly poorer health status. The effect is significantly stronger when dwellings need a major renovation than when they need a partial renovation.

[Table 4 about here.]

We next include individual fixed effects and exclude the moving individuals from the sample in order to ensure that the over-time variation in health status is not influenced by a change of neighborhood. The FE results are reported in columns 2, 4 and 6 of Table 4. We document that individuals living in a home that is in need of partial renovation are 1.1 percent more likely to report bad or poor health in a given year, and that they obtained 1.08 percent and 1.06 percent lower score on the mental and physical scale. The detrimental effect in health of those individuals living in a house in need of a major renovation is even stronger. Those individuals living in houses in need of a major renovation are 3.5 percent more likely to report bad or poor health status, perform 3.66 percent lower on the mental scale and 2.22 percent on the physical scale. The estimation results thus suggest that, on average, those who experience problems with their dwellings are less healthy; based on all model specifications and all subjective health measures included in the analysis, individuals living in worse-maintained houses report poorer levels of health.

5.2 Dwelling conditions and economic health consequences

We then examine the impact of housing conditions on healthcare utilization – as measured by the number of doctor visits – and on absence from work. Given the character of visits

to the general practitioner, we explore the effect of housing conditions on the question whether an individual visits the doctor or not, and, for those who do, on the number of visits. Columns (1) and (2) in Table 5 indicate that there is no significant effect of housing conditions on the likelihood of going to the doctor in the first place. But when we investigate further those respondents who reported visiting a doctor at least once in the last three months, columns (3) and (4) in Table 5, the estimation results show that those individuals living in homes in need for minor renovation report on average 3.71 percent higher number of visits and those in living in houses in need for a major renovation report 11.87 percent more visits to the doctor in the three months preceding the survey interview.

[Table 5 about here.]

Table 5 also reports results regarding absence from work. These effects turn out to be not as strong. We find some evidence of a relationship between dwelling conditions and sick leave, but when estimating the full model for the sample excluding the movers (which is our preferred specification) of the model, we find no statistically significant effect. So, the economic costs of poor housing conditions to society seem to mostly in terms of doctor visits rather than absence from work.

5.3 Heterogenous effects

Gender and age may also affect in the relationship between dwelling conditions and occupant health. Table 6 reports health results for gender, focusing on economic health outcomes: doctor visits and sick leave. As before, we first address the likelihood of going to the doctor and reporting sick, followed by the number of visits and days of sick leave for those who report a positive number of visits to the doctor or days on sick leave. Again, dwelling conditions do not seem to affect the likelihood of getting ill: we only find a small effect for the likelihood of men visiting the doctor, but only when their home is in need of a major renovation. The most interesting finding, however, is that gender turns out to play a key role in dwellings' health effects. For men we find no relationship between the dwelling's state and the number of doctor visits or sick leave. But for women, the effect

is quite strong: for women who visit the doctor, the number of visits is 5.7 percent higher when the home is in need of renovation, going up to 23.3 percent for a major renovation. So the findings reported in Table 5 seem to stem mostly from women. In contrast to this finding, we do not find any significant relationship between house conditions and days of sick leave when stratifying the results by gender.

[Table 6 about here.]

Table 7 presents results for five different age groups: respondents below 30 years old, 31-40, 41-50, 51-63 and those aged 64 and older. For the first age group, we do not find a significant relationship between house conditions and health, no matter whether we look at doctor visits or sick leave. However, for the 41-50 and 51-63 age groups, we find a statistically significant effect when homes are in need of a major renovation: these respondents visit their doctor respectively 17.5 and 31.2 percent more often than people of the same age who reside in a home in good condition. Regarding sick leave, we find no significant effect of age. And the effect is also strong for citizens aged 64 and older: if their home needs a partial renovation, they visit the doctor 5.6 percent more often, and increasing to 28.3 percent if the home needs a major renovation. So again, our overall results seem to be driven by a particular group of citizens: the elderly.

[Table 7 about here.]

This finding has some implications for the interpretation of our results, and of the possible mechanism that relates housing conditions and health outcomes. First, the fact that we document effects for doctor visits, but not for sick leave may be related to the age results reported above. Most of the overall effect seems to be driven by older citizens, who do not tend to work. So, if they fall ill, they may go to the doctor, but they do not take sick leave.

Second, the age effect points to two possible causal links between housing conditions and health outcomes. First, citizens who are more vulnerable to external health shocks are affected, while people with robust health are not. In that sense our result is in line with health outcomes of major heat waves, cold spells, or salmonella poisoning, which

have been shown to affect older citizens disproportionately (Bind et al., 2016). But the age effect may also be caused by differences in exposure. Those aged over 64 tend not to work and are therefore likely to spend more time at home, thereby increasing their daily exposure to adverse dwelling conditions. Indeed, the fact that we find a significant effect only conditional upon doctor visits rather than on the likelihood of visiting the doctor in the first place suggests housing conditions affecting chronic health, rather than leading to temporary "health shocks".

5.4 House conditions and health behavior

Estimating the relationship between dwelling conditions and occupant health is methodologically challenging. One of the major concerns is that the changes in house conditions over time are accompanied with other changes in life conditions or preferences of individuals. For instance, an individual exposed to an unexpected major negative income shock might reduce the investment in housing along with investment in health, for example by eating cheaper and less healthy food, or by cutting back on the costs associated with physical exercise, like a gym membership. It may also be possible that people who are less interested in health, and thus less willing to make health investments, are also less interested in a healthy living environment, and thus more likely to occupy a home in poor condition. If this would be the case, the findings reported in Tables 4 through 7 can not be interpreted as causal relationships.

In order to test whether housing conditions indeed affect health status and healthcare utilization rather than housing conditions and health status both being affected by lifestyle choices, we re-estimate the relationship between housing conditions and health outcomes and include variables concerning smoking into the regression equation, as well as the body mass index of individuals. Smoking is a direct indicator of health behavior, and although the body mass index of an individual does not reflect health behavior directly, it is a proxy commonly used in the literature as an indirect function of two other health-related consumption goods – nutrition and physical exercise. So, if the inclusion of smoking and the body mass index in the regression would reduce or even mitigate the previously established

effects of poor housing conditions, the causal relationship we inferred from Tables 4 through 7 would become doubtful. We include a dummy describing whether respondents smoke or not, as well as the number of cigarettes for the smokers, and we include the body mass index directly into the model.

We report estimation results in Table 8. The odd-numbered columns provide the estimation results without controlling for life-style variables, and the even-numbered columns provide results after their inclusion in the regression. The focus should be on the pairwise comparison of the house condition coefficients for the four health indicators: bad health, mental health, physical health, and doctor visits. It is clear that the inclusion of the life-style variables does not significantly change the housing condition effects. For mental and physical health, the life-style variables do not make any difference for the housing condition effect, no matter whether we the home is in need of for a partial or a full renovation. For bad general health and doctor visits, the housing condition coefficients changes slightly, but they seem to get stronger, rather than weaker. However, this may also be caused by a sampling effect, since we can only put the life-style controls into the bad health and doctor visits regressions for about a quarter of the observations that we have for the estimation without these controls.

[Table 8 about here.]

These results provide some indication that the evidence in Tables 4 through 7 is not likely to be caused by lifestyle choices that both affect housing and health investments, suggesting that causality indeed runs from housing conditions to health outcomes.

6 Concluding remarks

This study explores whether and how the state of a dwelling affects the health of its inhabitants. This seems an evident question to ask, given the amount of time we spend indoors, but it has not yet been investigated in a convincing way. The existing studies either do not establish causality clearly, or investigate housing conditions that are so extremely poor – often in slums or developing countries – that the results are not relevant for most

citizens of developed countries. Using the German socio-economic panel (SOEP) survey, we are able to identify clear causal links, while the data pertain to a representative cross-section of a highly developed country. In all, we have more than 300,000 respondent/year observations for the period between 1992 and 2014.

Our results show that inhabitants of poorly maintained dwellings report lower subjective health and visit the doctor 12 percent more often. Regarding doctor visits, we do not find a significant effect on the likelihood of visiting the doctor in the first place, but once people go to the doctor, they go significantly more often when they live in a dwelling in need of renovation. For sick leave, we find some evidence for the salience of house conditions, but not in the full model.

These effects are stronger when dwellings are in need of a major rather than a partial renovation. The results hold across income groups, and for both owner-occupiers and rental tenants. Given that our results stay robust controlling for body mass index, we infer that the effects we find are not caused by common underlying lifestyle choices, but that the causality does indeed run from housing conditions to health outcomes.

We also investigate whether age and gender affect these effects, and it turns out that they do. In fact, while women report up to 23 percent more visits to the doctor when they are exposed to poor housing conditions, we find no significant effect for men. For age, the results we find for the sample as a whole appear to be driven by the higher age groups. For age groups under 41, we find no significant relationship between housing conditions and health, while that relationship does show up for the age groups 41-50 and 51-63, and gets especially strong for those aged 64 and over. For the latter group, the effect is 5.6 percent, going up to 28.3 percent when the home is in need of a major renovation. This may explain the relatively weak results we find for sick leave as compared to doctor visits: those aged 64 and older do not tend to work, so they do not report sick for work, even if they are ill and have to go to the doctor.

The results presented in this paper indicate that the state of citizens' residence affects their health in a statistically and economically significant way, especially when these citizens get older. Apart from direct – but hard-to-measure – individual welfare effects, the economic costs for society mainly materialize in higher consumption of health services

rather than sick leave. These findings imply that investments in home improvement can have important positive external effects, which are currently not taken into account when evaluating such investments. As our societies grow older, these external effects will only increase.

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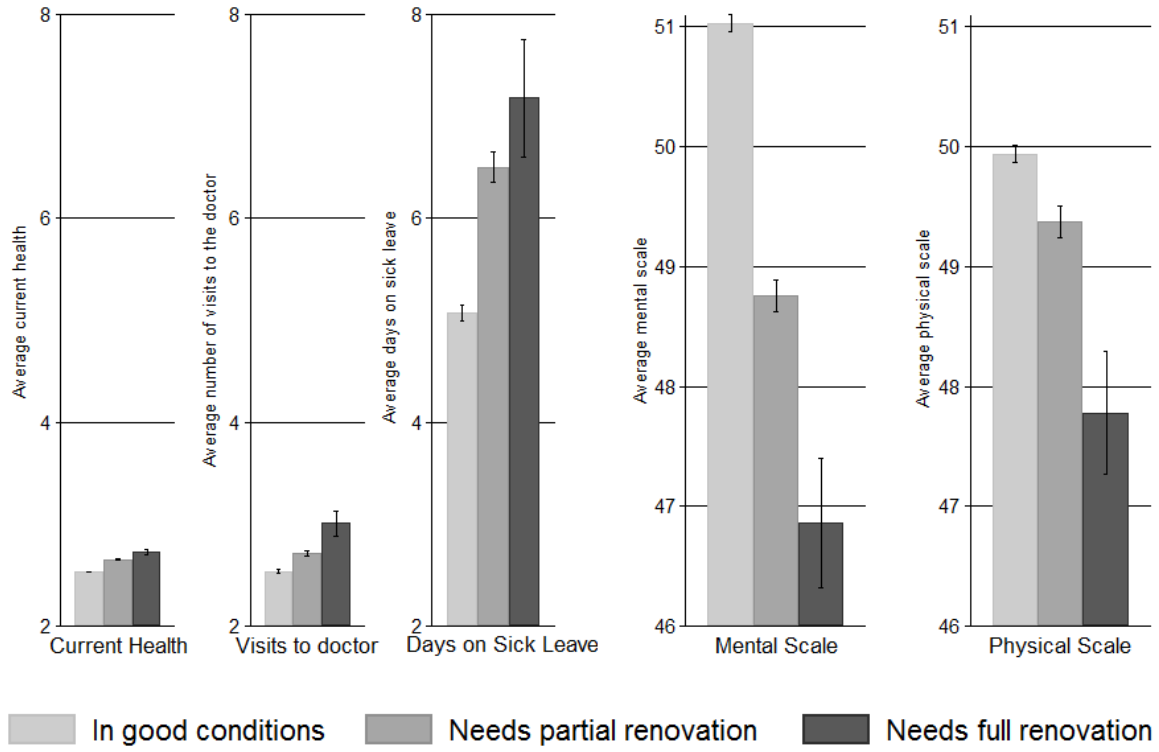
Figures

Figure 1: Housing condition and occupant health



Notes: Figure 1 presents the average level of health measures for different housing conditions. Current health ranges from 1 (very good health) to 5 (bad health). Mental and physical scales range from 0 to 100 (available for survey waves 2002, 2004, 2006, 2008, 2010, 2012 and 2014).

Tables

Table 1: Descriptive Statistics

	Mean	Std. Dev
Health Measures		
MCS: Summary Scale Mental (NBS)	50.38	10.03
PCS: Summary Scale Physical (NBS)	49.75	10.02
Current health status	2.57	0.97
Satisfaction with health status	6.78	2.24
Bad/Poor health (1=yes)	0.25	0.43
Visits to the doctor in the last three months	2.60	4.3
Number of days out sick previous year	5.51	20.76
Dwelling Characteristics		
House conditions		
In a good condition (1=yes)	0.71	0.46
In need of partial renovation (1=yes)	0.27	0.44
In need of major renovation (1=yes)	0.02	0.15
Number of years under bad conditions	0.74	1.77
Size of house unit (in sq m.)	106.12	47.02
Number of rooms larger than 6 sq m.	4.2	1.91
Latest possible construction year of dwelling	1,969.41	24.39
Amount of rent minus heating costs	467.82	238
Heating cost (in euros)	1,445.99	866.61
Dwelling has central, floor heat (1=yes)	1.04	0.28
Household Characteristics		
Monthly household net income (in euros)	2,713.11	1,964.13
Individual is a tenant or sub-tenant (1=yes)	0.48	0.50
Ratio household members per room	0.75	0.44
Household Typology 1-Pers.-HH (1=yes)	0.15	0.36
Couple without children (1=yes)	0.30	0.46
Single parent (1=yes)	0.06	0.25
Couple with children younger than 16 years (1=yes)	0.23	0.42
Couple with children older than 16 years (1=yes)	0.14	0.35
Couple with children younger and older than 16 years (1=yes)	0.08	0.27
Multiple generation household (1=yes)	0.02	0.14
Respondent Characteristics		
Age of respondent	46.21	17.41
Individual is working (1=yes)	0.59	0.49
Actual work time per week (in hours)	21.64	21.07
Amount of education or training (in years)	11.84	2.73
Individual holds a college degree (1=yes)	0.17	0.38

Notes: Mental scale and Physical scale health variables range from 0 to 100. "Current health status" variable ranges from 1 (very good) to 5 (bad). "Satisfaction with health status" variable ranges from 0 (very unhappy) to 10 (very happy).

Table 2: Household and dwelling characteristics per dwelling conditions

Housing conditions	(1) In good conditions	(2) In need of minor renovation	(3) In need of major renovation
Monthly household income	2858.13	2432.63	1978.54
	-2118.04	-1521.8	-1165.53
Age of respondent	47.15	44.04	42.22
	-17.57	-16.75	-16.31
Number of rooms	4.31	3.98	3.57
	-1.9	-1.79	-2.35
Size (in m2)	110.52	97.05	83.85
	-48.14	-42.45	-37.55
Construction year	1973.14	1960.95	1954.86
	-23.51	-24.25	-24.22
Value dwelling (in euros)	126417	71006.8	37833.23
	-189752	-131674	-112993
Monthly rent (in euros)	486.11	447.04	396.96
	-253.86	-216.43	-196.92
Tenant (1=yes)	0.42	0.62	0.82
Dwelling Type			
1-2 fam. house	0.37	0.29	0.19
1-2 Fam. rowhouse	0.20	0.16	0.11
Apt. In 3-4 unit bldg.	0.1 0	0.14	0.19
Apt. In 5-8 unit bldg.	0.18	0.22	0.29
Apt. In 9+ unit bldg.	0.10	0.13	0.15
High rise	0.01	0.02	0.03
Other building	0.00	0.00	0.01

Notes: Table 2 reports the descriptive statistics separated for different housing conditions. Standard deviations are reported in parentheses. Information "Value dwelling" is only available for years 2002, 2007, 2012.

Table 3; Housing conditions and health status

Panel A. Proportion of people reporting bad health status by dwelling condition for different age, income, and tenure groups

	Household Net Income				Respondent Age				Tenancy Status	
	1st quartile	2nd quartile	3rd quartile	4rd quartile	1st quartile	2nd quartile	3rd quartile	4rd quartile	Owner occupied	Rental house
In good condition	0.27	0.2	0.16	0.12	0.12	0.12	0.19	0.29	0.17	0.2
Need partial renovation	0.29	0.22	0.19	0.15	0.14	0.16	0.26	0.38	0.21	0.23
Need full renovation	0.33	0.28	0.2	0.18	0.17	0.22	0.37	0.47	0.29	0.28

Panel B. Mental health status by housing condition for different age, income and tenure groups

	Household Net Income				Respondent Age				Tenancy Status	
	1st quartile	2nd quartile	3rd quartile	4rd quartile	1st quartile	2nd quartile	3rd quartile	4rd quartile	Owner occupied	Rental house
In good condition	49.66	50.73	51.08	51.99	50.23	49.91	50.82	52.49	51.49	50.42
Need partial renovation	47.52	48.98	49.03	49.78	48.49	47.91	48.82	49.92	48.98	48.67
Need full renovation	45.06	47.45	49.3	49.38	47.69	47.15	45.34	46.94	46.88	46.85

Panel C. Physical health status by housing condition for different age, income and tenure groups

	Household Net Income				Respondent Age				Tenancy Status	
	1st quartile	2nd quartile	3rd quartile	4rd quartile	1st quartile	2nd quartile	3rd quartile	4rd quartile	Owner occupied	Rental house
In good condition	47.13	48.66	50.35	52.14	56.02	53.34	49.71	43.64	49.99	49.96
Need partial renovation	47.28	48.77	50.01	51.38	55.25	51.93	47.98	41.84	49.15	49.46
Need full renovation	45.39	49.08	50.92	52.13	54.63	51.34	46.07	39.59	48.41	47.75

Table 3 (continued); Housing conditions and health status

Panel D. Quarterly visits to doctor by housing condition for different age, income and tenure groups

	Household Net Income				Respondent Age				Tenancy Status	
	1st quartile	2nd quartile	3rd quartile	4rd quartile	1st quartile	2nd quartile	3rd quartile	4rd quartile	Owner occupied	Rental house
In good condition	3.07	2.67	2.41	2.18	1.82	2.01	2.6	3.58	2.46	2.64
Need partial renovation	3.05	2.7	2.55	2.42	1.97	2.24	3.01	4	2.63	2.76
Need full renovation	3.38	2.88	2.76	2.16	2.1	2.44	3.47	4.94	3.22	2.97

Panel E. Days on sick leave by housing condition for different age, income and tenure groups

	Household Net Income				Respondent Age				Tenancy Status	
	1st quartile	2nd quartile	3rd quartile	4rd quartile	1st quartile	2nd quartile	3rd quartile	4rd quartile	Owner occupied	Rental house
In good condition	4.7	5.53	5.78	4.68	4.69	6.06	8.42	1.68	4.49	5.92
Need partial renovation	5.92	6.8	7.16	5.82	5.49	7.45	9.82	2.26	5.64	6.85
Need full renovation	6.66	7.62	8.31	5.77	5.4	9.28	9.86	2.87	5.29	7.41

Notes: The table shows the average number of days on sick leave in each of the categories in "housing conditions". The results are presented for the different quartiles in the distribution of age and income, and for both (1) owner-occupied homes (2) rental homes.

Table 4: Estimation results housing conditions on subjective health status

	(1) Bad Health (1=yes)	(2) Bad Health (1=yes)	(3) Log of Mental Scale	(4) Log of Mental Scale	(5) Log of Physical Scale	(6) Log of Physical Scale
Housing conditions						
Need partial renovation (1=yes)	0.018***	0.030***	-0.025***	-0.011**	-0.014***	-0.015***
	[0.002]	[0.003]	[0.002]	[0.005]	[0.002]	[0.004]
Need major renovation (1=yes)	0.042***	0.074***	-0.056***	-0.059***	-0.025***	-0.026*
	[0.005]	[0.010]	[0.008]	[0.019]	[0.005]	[0.015]
Age of respondent	0.005***	0.005***	0.001***	-0.004***	-0.006***	-0.008***
	[0.000]	[0.000]	[0.000]	[0.001]	[0.000]	[0.000]
Log of monthly income	-0.026***	-0.038***	0.024***	0.027***	0.016***	-0.002
	[0.002]	[0.004]	[0.002]	[0.006]	[0.002]	[0.005]
Individual is working (1=yes)	-0.043***	-0.047***	0.027***	0.017*	0.029***	0.001
	[0.004]	[0.005]	[0.004]	[0.009]	[0.003]	[0.007]
Years of education	-0.010***	-0.009***	0.000	0.005	0.010***	0.002
	[0.001]	[0.001]	[0.001]	[0.004]	[0.001]	[0.003]
Ratio household members per room	-0.002	0.013**	0.005*	-0.004	0.005**	-0.011
	[0.002]	[0.005]	[0.003]	[0.011]	[0.002]	[0.008]
Observations	274,355	121,793	78,094	34,004	78,095	34,004
R-squared	0.186	0.152	0.004	0.013	0.027	0.033
Number of individuals	48,436	31,615	26,834	14,714	26,834	14,714
Socio-economic controls	YES	YES	YES	YES	YES	YES
Individual-fixed effects	NO	YES	NO	YES	NO	YES
Year-fixed effects	YES	YES	YES	YES	YES	YES
Movers excluded	NO	YES	NO	YES	NO	YES

Notes: Coefficients from year-fixed effects and socio-demographic controls not reported due to space limitations (available upon request). Heteroskedasticity-robust standard errors are in brackets. Standard errors are clustered at household level. *P<0.10. ** P<0.05. *** P<0.01

Table 5: Estimation results housing conditions and demand for health care

	(1) Visit doctor (1=yes)	(2) Visit doctor (1=yes)	(3) Visits doctor (>0)	(4) Visits doctor (>0)	(5) Sick leave (1=yes)	(6) sick leave (1=yes)	(7) Days sick Leave (>0)	(8) Days Sick Leave (>0)
House conditions								
Need partial renovation (1=yes)	0.006***	0.004	0.170***	0.154**	0.012***	0.005	1.059***	-0.342
	[0.002]	[0.004]	[0.029]	[0.065]	[0.003]	[0.007]	[0.250]	[0.698]
Need major renovation (1=yes)	0.009	0.01	0.515***	0.802***	0.001	0.016	2.893***	0.43
	[0.006]	[0.014]	[0.102]	[0.249]	[0.009]	[0.024]	[0.754]	[2.458]
Age of respondent	0.004***	0.006***	0.025***	0.009	-0.004***	0	0.410***	0.641***
	[0.000]	[0.001]	[0.001]	[0.010]	[0.000]	[0.001]	[0.014]	[0.112]
Log of monthly income	0.001	-0.007	-0.153***	-0.307***	0.010***	0.013	-2.555***	-2.865***
	[0.003]	[0.007]	[0.035]	[0.111]	[0.004]	[0.010]	[0.314]	[0.953]
Individual is working (1=yes)	-0.009*	-0.007	-0.322***	0.065				
	[0.005]	[0.010]	[0.064]	[0.150]				
Years of education	-0.001	-0.007**	-0.032***	0.014	0.002*	0.014**	-1.042***	-1.172**
	[0.001]	[0.003]	[0.010]	[0.049]	[0.001]	[0.006]	[0.075]	[0.586]
Household members per room	-0.013***	-0.009	-0.055	-0.06	-0.009**	-0.017	-0.222	-0.307
	[0.003]	[0.010]	[0.036]	[0.126]	[0.004]	[0.014]	[0.278]	[0.977]
Observations	274,355	121,793	176,933	80,613	158,379	61,082	80,605	30,102
R-squared	0.033	0.028	0.002	0.003	0.042	0.028	0.004	0.008
Number of individuals	48,436.00	31,615.00	39,114	23,682	34,212	20,304	24,704	13,277
Socio-economic controls	YES	YES	YES	YES	YES	YES	YES	YES
Individual-fixed effects	NO	YES	NO	YES	NO	YES	NO	YES
Year-fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Movers excluded	NO	YES	NO	YES	NO	YES	NO	YES

Notes: Coefficients from year fixed-effects and socio-demographic controls not reported due to space limitations (available upon request). Heteroskedasticity-robust standard errors are in brackets. Standard errors are clustered at household level. *P<0.10. ** P<0.05. *** P<0.01

Table 6: Estimation results housing conditions and demand for health care by gender

	Visit doctor (1=yes)		Number doctor Visits (>0)		Went on sick leave (1=yes)		Number days Sick Leave (>0)	
	(1) Men	(2) Women	(3) Men	(4) Women	(5) Men	(6) Women	(7) Men	(8) Women
House conditions								
Need partial renovation (1=yes)	0.002	0.005	0.069	0.221***	-0.005	0.015	-0.106	-0.527
	[0.007]	[0.006]	[0.098]	[0.084]	[0.010]	[0.011]	[1.043]	[0.947]
Need major renovation (1=yes)	0.036*	-0.012	0.665	0.906***	0.043	-0.014	1.695	-0.778
	[0.020]	[0.017]	[0.455]	[0.276]	[0.031]	[0.034]	[3.011]	[4.133]
Observations	57,380	64,413	35,401	45,212	32,908	28,174	16,399	13,703
R-squared	0.04	0.02	0.003	0.004	0.024	0.036	0.008	0.014
Number of individuals	15,011	16,604	10,792	12,890	10,687	9,617	7,159	6,118
Socio-economic controls	YES	YES	YES	YES	YES	YES	YES	YES
Individual-fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Year-fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Movers excluded	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Coefficients from year fixed-effects and socio-demographic controls not reported due to space limitations (available upon request). Heteroskedasticity-robust standard errors are in brackets. Standard errors are clustered at household level. *P<0.10. ** P<0.05. *** P<0.01

Table 7; Estimation results housing conditions and demand for health care by age group

PANEL A. Visits to the doctors

	Visit doctor (1=yes)					Number visits doctor (>0)				
	(1) Age Q1 (17-30)	(2) Age Q2 (31-40)	(3) Age Q3 (41-50)	(4) Age Q4 (51-63)	(5) Age Q5 (> 63)	(6) Age Q1 (17-30)	(7) Age Q2 (31-40)	(8) Age Q3 (41-50)	(9) Age Q4 (51-63)	(10) Age Q5 (> 63)
Housing conditions										
Need partial renovation (1=yes)	0.018	-0.014	-0.001	0.004	0.004	0.021	0.064	0.108	0.188	0.251**
	[0.015]	[0.013]	[0.011]	[0.009]	[0.007]	[0.155]	[0.158]	[0.154]	[0.146]	[0.114]
Need major renovation (1=yes)	0.019	-0.027	0.017	0.032	0.017	-0.065	-0.088	0.715**	1.278**	1.255***
	[0.041]	[0.035]	[0.033]	[0.029]	[0.020]	[0.896]	[0.449]	[0.354]	[0.574]	[0.442]
Observations	15,134	19,016	26,332	27,153	37,133	7,200	10,397	16,062	18,627	30,004
R-squared	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.007	0.005	0.005
Number of individuals	6,604	7,933	8,942	7,686	7,296	3,977	5,145	6,638	6,215	6,743

PANEL B. Sick leave

	On sick leave (1=yes)					Number days on sick leave (>0)				
	(1) Age Q1 (17-30)	(2) Age Q2 (31-40)	(3) Age Q3 (41-50)	(4) Age Q4 (51-63)	(5) Age Q5 (> 63)	(6) Age Q1 (17-30)	(7) Age Q2 (31-40)	(8) Age Q3 (41-50)	(9) Age Q4 (51-63)	(10) Age Q5 (> 63)
Housing conditions										
Need partial renovation (1=yes)	0.012	-0.004	0.005	0.005	-0.001	-0.62	2.438	1.507	-2.848	-12.638
	[0.015]	[0.013]	[0.011]	[0.010]	[0.002]	[1.213]	[1.612]	[1.310]	[1.832]	[8.206]
Need major renovation (1=yes)	-0.026	0.009	0.021	0.037	-0.006	5.571	-1.635	0.548	3.718	-5.207
	[0.030]	[0.037]	[0.037]	[0.025]	[0.006]	[4.766]	[4.497]	[2.665]	[8.911]	[15.355]
Observations	14,221	18,464	25,863	26,381	36,306	4,996	7,512	11,311	8,756	591
R-squared	0.000	0.000	0.000	0.000	0.000	0.000	0.035	0.042	0.090	0.205
Number of individuals	6,409	7,915	8,929	7,658	7,279	3,075	4,277	5,252	3,781	426

Notes: Coefficients from year fixed-effects and socio-demographic controls not reported due to space limitations (available upon request). Movers are excluded from all model specifications. Heteroskedasticity-robust standard errors are in brackets. Standard errors are clustered at household level. *P<0.10. ** P<0.05. *** P<0.01

Table 8: Estimation results housing conditions and health status controlling for health behavior (body mass index and smoking behavior)

	(1) Bad Health (1=yes)	(2) Bad Health (1=yes)	(3) Log of Mental Scale	(4) Log of Mental Scale	(5) Log of Physical Scale	(6) Log of Physical Scale	(7) Visits doctor doctor	(8) Visits doctor doctor
Housing conditions								
Need partial renovation	0.011***	0.007	-0.011**	-0.011**	-0.015***	-0.015***	0.148***	0.262**
	[0.004]	[0.009]	[0.005]	[0.005]	[0.004]	[0.004]	[0.049]	[0.107]
Need major renovation	0.039***	0.071**	-0.059***	-0.059***	-0.026*	-0.026*	0.680***	1.040***
	[0.012]	[0.031]	[0.019]	[0.019]	[0.015]	[0.015]	[0.177]	[0.348]
Number of Cigarettes Per Day		-0.001		-0.001		0.000		-0.006
		[0.001]		[0.001]		[0.000]		[0.011]
Currently Smoke (1=yes)		0.008		0.005		0.009		-0.255
		[0.016]		[0.009]		[0.007]		[0.175]
Body-Mass-Index		-0.003*		0.005***		-0.004***		-0.062***
		[0.002]		[0.001]		[0.001]		[0.021]
Age of respondent	0.011***	0.010***	-0.004***	-0.004***	-0.008***	-0.007***	0.032***	0.021*
	[0.001]	[0.001]	[0.001]	[0.001]	[0.000]	[0.000]	[0.007]	[0.011]
Observations	121,793	34,532	34,004	33,672	34,004	33,672	112,588	34,531
R-squared	0.155	0.015	0.013	0.015	0.033	0.034	0.003	0.005
Number of Individuals	31,615	14,738	14,714	14,573	14,714	14,573	28,081	14,737
Socio-Economic controls	YES	YES	YES	YES	YES	YES	YES	YES
Individual FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES
Movers excl.	YES	YES	YES	YES	YES	YES	YES	YES

Notes: Coefficients from year-fixed effects and socio-demographic controls not reported due to space limitations (available upon request). Heteroskedasticity-robust standard errors are in brackets. Standard errors are clustered at household level. *P<0.10. ** P<0.05. *** P<0.01