The Impact of Housing Conditions on Health Outcomes

Juan Palacios
Massachusetts Institute of Technology
jpalacio@mit.edu

Piet Eichholtz
Maastricht University
p.eichholtz@maastrichtuniversity.nl

Nils Kok [*]
Maastricht University
n.kok@maastrichtuniversity.nl

Erdal Aydin[†]
Sabanci University
erdalaydin@sabanciuniv.edu

Abstract

We investigate the relationship between housing conditions and health outcomes using a dataset that tracks 25,000 German households over 25 years. We document that individuals exposed to poor housing conditions report worse mental and physical health, and experience an 11 percent increase in doctor visits, increasing to 20 percent for age groups over 64. The analysis controls for individual, dwelling and temporal fixed effects, and is robust to changes in socio-economic status, lifestyle choices, and neighborhood conditions. As a robustness check, we use home renovations as major a trigger of changes in housing conditions. Restricting the analysis to tenants, whose renovations are paid by landlords, we document that home renovations significantly reduce doctor visits, corroborating the findings on home conditions and health outcomes.

JEL Codes: I12, I14, Q53, R38

---

1   INTRODUCTION

Increasing welfare and longevity, and the corresponding rise in the demand for health services, are confronting modern society with rapidly rising healthcare costs. Projections of these costs for 2040 are as high as 18.5 percent of U.S. GDP, 12.7 percent of German GDP, and 9.6 percent of U.K. GDP, for example (Dieleman et al., 2017). Understanding the causes of health deprivation, and providing solutions towards prevention, present an increasingly critical challenge for academia, private market participants, and policymakers.

Housing and the built environment play a major role in shaping human health. Historically, inadequate housing has fueled the spread of disease, affected individuals' physical and mental health, and increased mortality (Rosen, 2015). Slum clearance, sanitation and provision of affordable housing are just some examples of public health policies enacted in modern history to ensure healthy living conditions (Shaw, 2004). The provision of adequate housing should lead to increased human wellbeing, and subsequently lower healthcare costs. Yet, limited evidence exists to support these claims, with the current evidence mainly focused on the health effects of outdoor hazards in the area surrounding homes.

Indeed, the relationship between outdoor environmental issues and human health has been well established in the literature. Numerous studies provide quasi-experimental evidence of the causal link between environmental hazards such as extreme temperatures or air pollution and human health (for a review see Deschenes, 2014; Graff Zivin and Neidell, 2013). The literature has documented the effects of such external effects on a variety of health outcomes, including mortality rates (Barreca, 2012; Deschênes and Greenstone, 2011; Ebenstein et al., 2017), infant mortality rates (Currie and Neidell, 2005; Luechinger, 2009), (low) birth weights (Currie et al., 2015), school absence (Currie et al., 2009), work hours (Hanna and Oliva, 2015), and respiratory and heart-related hospital admissions (Schlenker and Walker, 2016).

However, indoor environmental conditions are not merely a by-product of outdoor environmental conditions, and while there is some research concerning the impact of indoor conditions on human health, such evidence is mainly based on small-scale intervention studies and in settings not typically applicable to the average dwelling in developed economies

(Cattaneo et al., 2009; Barron and Torero, 2017; Galiani et al., 2017; Imelda, 2018). A recent paper in this literature is Kuenn and Palacios (2017), who analyze the health implications of a large housing renovation program in East Germany that was sponsored by the German government after reunification.[1]

The aim of this paper is to estimate the impact of housing conditions on health outcomes in a setting representative of dwellings in modern societies having a higher-quality housing stock. Research results for housing in that setting is virtually non-existent. Addressing this knowledge lacuna is important, given that 90 percent of an individual's time is typically spent indoors (Klepeis et al., 2001). People are working in office buildings, living in their homes, and spending leisure time in shopping malls, restaurants, the gym, etc.

Empirically assessing the consequences of deficient housing conditions on human health is challenging. First, large data samples with standardized measures of housing conditions and occupants' health are generally not available. As opposed to relying on small-scale intervention studies, this study takes a different approach to explore the impact of housing conditions on health outcomes, and the subsequent demand for healthcare. 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 human health, we exploit the German Socio Economic Panel (GSOEP). Starting in 1984, this dataset is, to the best of our knowledge, the longest individual-level dataset that provides information on both health and housing conditions (Wagner et al., 2007). Each participant is interviewed, individually, and asked to evaluate the condition of their dwelling, as well as to complete an extensive questionnaire on subjective health status and on their demand for healthcare, objectively measured by the number of visits to a doctor and the days of sick leave.[2]

---

[1] The authors show that in the 1990s, the amenities of houses in the former German Democratic Republic (GDR), based on the poor construction standards of the Soviet block, were upgraded to Western standards. As described by the authors, at the beginning of their sample period 52 percent of the houses did not have central heating systems and over 26 of the houses lacked an indoor bathtub or shower. These conditions are far from representative of current housing standards in affluent countries, and policy relevance for that type of countries is therefore limited.

[2] The fact that data is explained and collected by an interviewer rather than an online survey mitigates some of the concern about the subjectivity of one of our variables of interest, the home maintenance condition.

Second, since individuals with a higher socio-economic status presumably live in better maintained dwellings and in low-poverty areas, it is difficult to separately distinguish the effect of housing conditions from the effect of variables comprising the socio-economic profile of individuals. The participation of individuals in the GSOEP over long periods of time allows researchers to observe the same individual, exposed to varying housing conditions, over the sample period. In our empirical specification, we estimate the impact of housing conditions on health outcomes with individual and dwelling-fixed effects, exploiting the changes in health outcomes associated with within individual variation in housing conditions.

Third, one of the most problematic time-varying factor is the set of characteristics of the home. A key instrument to improve housing conditions is moving to a new home. However, the potential improvement in individuals' health might well coincide with improvements in the characteristics of the neighborhood. We introduce individual-dwelling fixed effects to control for time-invariant, unobserved and idiosyncratic characteristics of participant's homes. This way, we exploit variations in individuals' housing conditions over time, while keeping the home address constant, avoiding potential confounding factors associated with moving to a new home (e.g. moving to a healthier home and a healthier neighborhood environment).

Last, there is the important question of self-selection into home renovation. Home owners decide themselves whether to renovate or not, but for tenants, this decision is made by a landlord and is exogenous to the tenant, so a focus on tenants addresses potential endogeneity biases. In many countries, however, the rental housing sector caters to the poorest parts of society only, compromising the external validity of the findings. Low-quality housing is likely to be occupied by low-income inhabitants who tend to be in poorer health than the population as a whole, making generalization of the findings difficult. But in Germany, over the sample period considered in the analysis, home ownership was about 50 percent, among the lowest in the world. By specifically analyzing tenants in a German dataset, we minimize renovation endogeneity without compromising the external validity

of our findings.[3]

The results from the empirical analysis show that the effects of housing conditions on health outcomes are substantial. Those individuals living in dwellings with a poor indoor environment experience an 11 percent increase in demand for healthcare, as reflected in the number of visits to the doctor. The effects show substantial heterogeneity based on dwelling conditions, and hold across income groups. Moreover, the effects of poor housing conditions on medical service consumption increases with age. Results from our analysis of subjective health measures (the SF-12 questionnaire) suggest that the increase in demand for healthcare 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.

We corroborate our results using an event study around the occurrence of (exogenous) home renovations. We restrict the analysis to tenants, as the decision to renovate a home is made by a landlord, and is thus exogenous to the tenant's health. We document that home renovations significantly reduce doctor visits, confirming the findings on home conditions and health outcomes.

Finally, we study avoidance behavior of individuals as it relates to to housing conditions. Individuals can avoid or reduce their exposure to poor housing conditions by either moving or by renovating their home. We observe that individuals living in a poorly maintained home have a higher propensity to move, with remarkably similar effects for homeowners versus tenants. However, when investigating renovations, we observe evidence of underinvestment in the rental housing market due to the presence of external effects – landlords have to make investments, which benefit tenants' health rather than generating direct economic outcomes for the landlord. Owner-occupiers living in homes that need a major renovation show a likelihood of about 23 percent to renovate their home, while the likelihood of home renovation of poorly maintained rental homes is less than 5 percent, prolonging tenants' exposure to unhealthy housing conditions.

---

[3]Of course, this assumes that tenants have limited bargaining power over their landlords. Given that 58 percent of the German rental stock is owned by corporate and public housing companies, violation of this identifying assumption seems implausible – after all, these companies are unlikely to tailor the timing of renovation programs to the specific needs of individual tenants.

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 present the methodology, 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 using the theoretical model of Grossman (1972), where individuals are born with a stock of health capital that depreciates over the years and increases through different health 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 economics has documented the relationship between different aspects of individuals' living conditions and their health status in multiple domains. In the socioeconomic domain, studies using self-reported health indicators from different countries such as the U.S., 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 a measurably improved physical and mental health and well-being status (Ludwig et al., 2012).

The impact of the living environment on individuals' health is not limited to socioeconomic channels. The literature 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 surroundings the dwelling, they are not 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 such 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.

Although people in developed economies spend, on average, 90 percent of their time indoors, not much is known about the impact of buildings on health outcomes. The existing knowledge regarding 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 conditions (e.g. bad lighting and ventilation, presence of 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 the causal effects that housing conditions may have on health outcomes.

Intervention studies allow researchers to isolate biological impacts, but generalization of their results tends to be limited by small sample sizes and the unique characteristics of the participants. Indeed, reviewing the experimental medical literature 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 improvements of the housing stock.

A third strand of literature on indoor conditions and health outcomes is based on quasi-experimental studies that involve policy interventions in slums or developing countries, where socio-demographic characteristics differ fundamentally from those of the average household in the United States or European Union. For example, Cattaneo et al. (2009)

study 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. Barron and Torero (2017) explore the implications of a randomized controlled trial in El Salvador, where households were granted discount vouchers to connect to the electricity grid. The estimation results show significant drops in respiratory infections among children, associated with a decrease in $PM_{2.5}$ after connecting the dwellings to the grid. Galiani et al. (2017) report significant improvements in children's health followed by the provision of prefabricated houses to slum dwellers in Latin America. Coal cooking stoves are another major source of indoor air pollution in the developing world. Smith-Sivertsen et al. (2009) document significant improvements in lung function and a reduction in respiratory symptoms followed by the provision of upgraded cooking stoves in Guatemala, but Hanna et al. (2016) found no effects in a similar intervention in India. However, it remains an open question whether dwelling conditions also have such significant health effects when the baseline quality of housing is quite good already, as will likely be the case in developed 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 housing conditions and occupant health status, as well as other household characteristics that are likely to affect health outcomes. The German Socio-Economic Panel (GSOEP, v31) provides a panel dataset, with annual information on individual health and housing conditions since 1984, covering more than 20,000 individuals and 11,000 households at any given time (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 the health situation of individuals. In addition, the survey includes extensive information on tenure choice, 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 1990 through 2014.[4] Our full sample includes 57,581 adults (30,151 women and 27,430 men) and a total of 24,849 households. The average duration that an individual is included in the survey is 6.48 years (standard deviation = 5.27), with a maximum of 23 years.

3.1 Health Outcomes

The GSOEP provides information on several health metrics. In this paper, we focus on three different health outcomes to establish the link between housing 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 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). The measures are constructed based on the answers of participants to the health SF-12 questionnaire. This questionnaire is included in the GSOEP 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 a better health status).[5]

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).[6] This question is included in the GSOEP for every wave since 1992, except for 1993. Self-assessed health measures are commonly used in empirical studies to explore the dynamics of health in a given 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 construct a measure of bad health status from this 5-point Likert scale that takes the value of one if the individual

---

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

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

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

reports being in bad or poor health, and zero otherwise.

We use the number of visits to a doctor as a quantitative 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 demand for healthcare (e.g. Pohlmeier and Ulrich, 1995; Winkelmann, 2004; Santos Silva and Windmeijer, 2001) The survey included this question in every wave since 1991, except for 1993 and 1994. We explore the effect of housing conditions on healthcare utilization based on two measures: (1) visiting the doctor at least once during the past three months (yes/no), and (2) the number of doctor visits in the last three months. We also explore the days on sick leave reported over the last year.

Finally, we use the body mass index (BMI) and whether people smoke as measures of health behavior. "Good health behavior" refers to the different activities undertaken by individuals to maintain or improve their health status, or to prevent illness. Typical examples include exercise, (quitting) smoking, or (healthy) nutrition. In the literature of health economics, the body mass index and smoking are often used to capture the effect of health behavior on health status (Künn-Nelen, 2016; Reinhold and Jürges, 2010).

3.2   Housing Conditions

We evaluate the condition of participants' dwellings based on self-assessment by the individuals. Each year, all survey participants 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?". [7] Based on the answer provided 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.[8]

Out of the 56,459 survey participants for whom the information on housing conditions is available, 28,635 participants lived at least one year in a house in need of a minor renovation,

---

[7]As indicated before, data is collected by an interviewer rather than an online survey, which mitigates some of the concern about the subjectivity of the home maintenance condition.

[8]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.

and 4,856 participants lived at least one year in a home in need of a major renovation. Those individuals that report living in a house in need of repairs experience between two and three years of deficient housing conditions, on average. Our estimation strategy focuses on those participants that experience deficient housing conditions for a part of the period in which they appear in the survey. In addition, each year SOEP participants report the advent of a major house renovation in the year preceding the date of the interview.

3.3 Socio-Demographic Characteristics

In the analysis, we control for the following socio-demographic characteristics: age, household composition, household income, marital status, employment status (whether the individual is working or not, and whether there was 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), and gender. These variables are commonly used in the literature as determinants of health outcomes, sick leave, and demand for healthcare (e.g. Adams et al., 2003; Contoyannis et al., 2004; Currie et al., 2009). In addition, we also have information about the ratio of household members to the number of rooms in the house and whether the household owns or rents the home. The latter is important for our identification strategy: while the rental housing market in some countries caters only to the poor, this is not the case in Germany. Renting a home is common in Germany, also for relatively well-off citizens. The German homeownership rate is currently just 51.9 percent, among the lowest in the world.

3.4 Descriptive Statistics

Table I 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 report 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.

Regarding dwelling conditions, 54 percent of participants always report that their home

is in good condition, while 39 and 7 percent report the need for a partial or major renovation in their homes for at least one of the survey years, respectively.

[Table I]

We first compare average health outcomes based on different housing condition categories, using some simple visualizations. As illustrated in Figure I, individuals living in homes in need of partial or full renovation systematically 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 on the mental scale. Moreover, individuals in poorly maintained homes report a significantly higher number of visits to the doctor in the three months preceding the date of the survey, as well as more days of sick leave. Participants living in dwellings in good condition report about 2.5 doctor visits and take about five days of sick leave, compared to more than three visits and seven days of sick leave for those living in a home that needs a full renovation.

[Figure I]

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 II 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 rental tenants rather than owners.

[Table II]

Thus, the relationship between health and housing conditions could be driven merely by socio-economic factors that determine both dwelling choice and health, which would affect our inferences regarding the association between housing conditions and health. In

11

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 inhabit better homes, so the apparent relations documented in Figure I might be determined by differences in socioeconomic status. Another potential confounding variable is tenure status. Poorer people are more likely to live in rental housing, which tends to be maintained poorly compared to owner-occupied housing (Pollack et al., 2004).

Table III provides further insight into 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 five different health indicators: bad health status, mental health scale, physical health scale, doctor visits, and days of sick leave. As expected, the statistics indicate that higher income, lower age, and homeownership are all associated with better health outcomes. However, the descriptive statistics also show that the detrimental health effect of poor housing conditions holds within almost any age or income group in the sample, and likewise for homeowners and tenants, no matter how health is measured. Interestingly, the statistics reported in Table III suggest that the relationship between poor housing quality and health status is stronger for older and lower-income respondents as compared to higher paid and younger people.

[Table III]

4 EMPIRICAL STRATEGY

The associations between housing conditions and health outcomes are manifold and complex, and an empirical analysis requires the consideration of numerous confounding factors. Investment decisions in health and individual preferences for dwellings are driven by a set of observable and unobservable household and individual characteristics. Furthermore, both are likely to be determined by some common circumstances, possibly biasing the estimated effect of housing conditions on health.

In order to identify the impact of housing conditions on individuals' health, we propose

the following reduced-form empirical model:

$$Health^*_{i,d,t} = \beta Housing\_Conditions_{d,t} + \lambda X_{i,t} + \delta Z_{d,t} + \alpha_i + t_t + \epsilon_{i,d,t} \qquad (1)$$

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. $Housing\ conditions_{d,t}$ represents the conditions of the dwelling d at time t. The vector $Housing\ conditions_{d,t}$ 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 vectors $X_{i,t}$ and $Z_{d,t}$ include all the individual and dwelling control variables, respectively. The unobserved component of the model includes the time-invariant idiosyncratic effects, α_i, time (year) fixed effects, t_t, and a normally distributed error term, $\epsilon_{i,d,t}$. Based on this model, the parameters of interest, elements of β, represent the effect of dwelling conditions on the health outcomes of individuals.

As discussed earlier, estimating the causal link between dwelling conditions and occupant health is methodologically challenging. The literature acknowledges the existence of multiple confounders, or variables affecting both the preferences of an individual for the dwelling and his investments in health. The presence of such unobserved factors hinders the proper estimation of the link between dwelling conditions and health using a cross-sectional analysis. We therefore employ the longitudinal nature of our dataset to alleviate concerns about potential endogeneity issues.

First, the over-time variation in the data allows for the estimation of fixed effects models in which the unobserved time-invariant characteristics of individuals can be properly controlled for. The individual-fixed effect approach estimates the impact of poor housing conditions on occupant health based on the variation in housing conditions over time for the same individual.

However, individual-fixed effects alone will likely not be sufficient to control for all unobservables, as 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 impact of housing conditions on health from any neighborhood confounder, we therefore implement an individual-dwelling fixed effect analysis where we exploit the variation in individuals' housing conditions within a specific dwelling. We construct an individual-dwelling identifier by combining the personal identifier of each respondent and the date the respondent moved to the current dwelling.[9] So the fixed effects strategy we employ controls for both personal and dwelling time-invariant characteristics in the estimations. In effect, the simultaneous inclusion of both types of fixed effects implies that we follow the same inhabitants of the same dwellings through time.

A further concern in the estimations is the self-selection into home renovations. It is possible, for example, that less healthy individuals underinvest in home renovation, or that individuals facing an adverse health shock simply have fewer resources for home maintenance. However, that would only be an issue for homeowners, and not for tenants. In rental housing, maintenance and renovation decisions are taken by the landlord, and are exogenous to the tenant's health status.[10] Our initial analysis focuses specifically on respondents in rental homes. Germany's housing market is characterized by a relatively dominant position of rental homes, mostly owned by institutional housing providers. Indeed, approximately 50 percent of the GSOEP participants are tenants. That means renting a home is not limited to the lower social strata of German society. In many other countries, renting is limited to the lower-income parts of society, involving low-quality housing and inhabitants who would likely be less healthy than the population as a whole. This would make it hard to generalize the findings. Our focus on Germany addresses these concerns.

As a final check on the role of potential confounders that may simultaneously affect

---

[9]The GSOEP contains information about the exact moving date for each respondent in the sample.

[10]Germany has very strict privacy laws, so landlords do not know about personal issues, like the frequency with which their tenants visit the doctor. To test whether the timing of renovation is indeed exogenous to tenants' health, we investigate whether the different aspects of health status affect the likelihood of dwelling renovation by the landlord. The results, depicted in Table A1 in the Appendix, clearly show that none of the health aspects employed in this paper (bad health status, mental health, physical health, and doctor visits) is significantly related to subsequent renovation likelihood.

housing choice and health outcomes, we test for the confounding role of health behavior channels. In particular, we consider the effect of the body mass index and smoking behavior of respondents. The body mass index (BMI) is widely used as an indicator of health investments by individuals (e.g. Künn-Nelen, 2016; Reinhold and Jürges, 2010), and it is closely related to individuals' nutrition and lifestyle. Smoking is an often-used indicator of an unhealthy lifestyle choices (Cutler and Glaeser, 2005). These two measures serve as indicators of health preferences and potential changes in individuals' budget constraints, not captured by our other controls. We test whether these measures are related to housing conditions. If not, we can conclude that their role as a possible confounding factor is limited, providing more confidence in the direct relationship between housing conditions and health outcomes.

5   RESULTS

5.1   *Effects of Dwelling Conditions on Health Outcomes*

We first estimate the model specified in equation (1) using pooled OLS to investigate whether housing conditions affect subjective health status, using the "bad health" perception indicator, the mental health scale, and the physical health scale as dependent variables. The OLS estimation results are reported in Table IV, columns 1, 4, and 7. For each of the health indicators, we document that individuals living in homes in need of renovation report a significantly deteriorated health status. The effect is significantly stronger for dwellings that need a major renovation as compared to dwellings that need a partial renovation.

[Table IV]

We include dwelling-individual fixed effects in order to ensure that the over-time variation in health status is not influenced by unobserved characteristics of individuals, dwellings, or a change of neighborhood. The fixed-effect results are reported in columns 2, 5 and 8 of Table IV. 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 these

15

individuals obtained an 0.8 percent and 1.7 percent lower score on the mental and physical scales, respectively. The detrimental effect on health for those individuals living in a home in need of a major renovation is significantly stronger. Those individuals living in poorly maintained homes are 2.7 percent more likely to report a bad or poor health status, score 2.3 percent lower on the mental scale, and 3.7 percent lower on the physical scale, during those years that their homes were in need of a major renovation. 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, exposure to homes that are anything less than well-maintained is related to deteriorated health outcomes.

In columns 3, 6 and 9 of Table IV we restrict the estimation to the tenants in the sample, to address endogeneity concerns regarding the renovation decision. The empirical results remain robust, with coefficients comparable to those reported before. Tenants whose home needs renovation are less healthy, both physically and mentally.[11]

5.2   Dwelling Conditions And Economic Outcomes

We then examine the impact of housing conditions on healthcare utilization - as measured by the number of doctor visits - and on absence from work. We investigate the impact of housing conditions and demand for healthcare on both the intensive and the extensive margin. Given the character of visits to the general practitioner, we explore the effect of housing conditions on whether an individual visits the doctor at all, as well as on the total number of visits. As before, columns 1, 4 and 7 present outcomes of the pooled OLS analysis, and columns 2, 5, and 8 show the results of the fixed-effect analysis. Columns 1, 2 and 3 of Table V indicate that there is no significant effect of housing conditions on the extensive margin, i.e. the likelihood of going to the doctor in the first place. But when investigating the intensive margin, columns 4,5 and 6 of Table V, the estimation results

---

[11]We control for household income, marital status and employment status in the regressions, but is may be possible that housing conditions would reversely affect household income, leading to endogeneity biases. In order to confirm robustness, we have done our main regression without controlling for tenancy status, household income and employment status. This does not markedly affect the coefficients for our variables of interest, i.e. those concerning renovation status.

show that living in a home in need of partial renovation is associated with an increase of 4.35 percent (0.060/2.612) in doctor visits, as compared to living in well-maintained homes. These differences are even larger for those living in a home in need of a major renovation, leading to an 11.2 percent increase in visits to the doctor in the three months preceding the survey interview, as compared to living in a dwelling that is in good condition. The results for the tenant sample, presented in column 3, 6, and 9, are consistent with those in the full sample.

Table V also reports results regarding absence from work. We find some evidence of a relationship between dwelling conditions and sick leave when employing the OLS specification, but when estimating the full model that takes into account unobserved individual and dwelling specific characteristics, we find no statistically significant effect. Thus, the economic costs of poor housing conditions seem to translate mostly in an increase in demand for healthcare, as reflected by the increase in number of visits to the doctor, rather than absence from work. However, the insignificant effect on presence at work does not imply that productivity, a critical factor for employers, is unaffected by poor housing conditions.

[Table V]

5.3 *Heterogenous Effects*

This subsection further analyzes the potential heterogeneity in the impact of housing conditions on occupant health. In particular, we explore the role of age as mediating channel between housing conditions and health outcomes.[12]

The differences in health status associated with housing conditions seem to be augmented over the lifetime of an individual. Tables VIA and VIB provide the results regarding age effects, based on the fixed-effects models. The tables show marginal effects of housing conditions on doctor visits and sick leave for five different age groups: respondents below 30 years old, 31 through 40, 41 through 50, 51 through 63, and those with an age

---

[12]We find no evidence of heterogeneous effects in the detrimental impact of inadequate housing conditions on health outcomes relative to gender and income groups. While the descriptive statistics show that lower income groups are more likely to be exposed to poor housing conditions, the effects of deficient housing are similar for them as compared to higher income groups. Results available upon request.

of 64 and older. For the youngest group, we do not find a significant relationship between housing conditions and health, no matter whether we look at doctor visits or sick leave. However, for the 31-40 and 41-50 age groups, we find a marginally statistically significant (at 10 percent) effect on doctor visits when homes are in need of a major renovation: these respondents visit their doctor respectively 25 percent more often than people of the same age who reside in a home that is in good condition. The documented effect is strongest for citizens aged 64 and older: if their home needs a partial renovation, they visit the doctor 6 percent more often, increasing to 20 percent if the home needs a major renovation. So, our overall results seem to be driven by a particular group of citizens: the elderly. [13]

For sick leave, we generally find no statistically significant results, except for the 41-50 age group. When they inhabit homes in need of a partial renovation, their sick leave is 1.34 days (24.3 percent) higher than people of the same age group who live in a home that is in a good condition. For those living in home that is in need of a major renovation, the coefficient increases to 1.75, but is no longer statistically significant.[14] The fact that we do not find any effects in the older age cohorts is most likely due to low labor market participation. In the 51-63 age group, labor market participation in Germany decreases quite rapidly.

[Table VI]

Figure II shows the conditional average scores in mental and physical health for individuals living in houses in good condition, and those living in houses that need a major renovation. The conditional means are based on the residuals of the regression of mental and physical scales on a set of socio-demographic controls (i.e. income, gender, labor status, education, and household member per room). While the differences between the two

---

[13]To explore age heterogeneity further, we have also looked at health effects for children. The German Socio Economic Panel (GSOEP) recently created a dataset monitoring the development of children from birth to the age of 10 (Goebel, 2017). Unfortunately, the sample size is substantially smaller than the original adult sample. In total, the dataset contains 12,661 children, but enough information regarding the questions relevant to our study has been provided for only 139 children. When we employ our fixed-effect specification for the children sample, using the weight of the child, parental income, tenancy status and working status as controls, we find some evidence that housing conditions affect children's health.

[14]It is quite possible that this is due to relatively low statistical power: whereas we have over 15,000 observations in age group 41-50 for dwellings that need a partial renovation, we have just 1,100 observations (approximately 300 participants) in that age group for homes in need of a major renovation.

groups are relatively small in early adult life, the differences become more pronounced in later years. As the respondents get older, the health gap associated with housing conditions grows.

[Figure II]

These findings have some implications for the interpretation of our results, and for the possible mechanism that relates housing conditions to 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 due to poor housing conditions, they may go to the doctor, but they do not take sick leave.

Second, the age effect points to two possible channels between housing conditions and health outcomes. First, it is possible that citizens who are more vulnerable to external health shocks are affected, while people with a 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 determined by differences in exposure. Those individuals of 64 years and older tend not to work and are therefore likely to spend more time at home, thereby increasing their daily exposure to adverse dwelling conditions. Unfortunately, our dataset does not allow us to explore this further, given that the information about housing conditions does not provide the specific aspects of what makes housing conditions "poor".[15]

5.4 *Robustness Checks*

Health status, home maintenance, and health outcomes

One of the major concerns in estimating the relationship between dwelling conditions and occupant health is that the changes in housing conditions over time are accompanied

---

[15]Other national household panel surveys, such as those for the United Kingdom and the Netherlands, provide more specific information about exact housing conditions, including dampness, rot, black mold, and noise. Exploring these datasets may provide more insight into the mechanisms between housing conditions and health outcomes.

with other changes in either 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 are thus more likely to occupy a home that is in a poor condition. If this would be the case, the findings reported in Tables IV through VI cannot 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 first estimate the effects of housing conditions on health behavioral measures. We then re-estimate the relationship between housing conditions and health outcomes, including smoking as well as the body mass index of individuals as health behavior measures. If the inclusion of smoking and the body mass index in the regression would reduce or even nullify the previously established effects of poor housing conditions, that would call into question the causal relationship inferred from Tables IV through VI. We include a dummy that reflects 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 for the fixed-effects models in Table VII. In columns (1) and (2) we provide the estimation results regarding the impact of housing conditions on occupants' body mass index and smoking behavior. The estimation results show that housing conditions have no significant impact on individuals' health behavior outcomes. The body mass index and smoking behavior of those individuals living in poorly maintained homes do not differ significantly from those individuals living in homes that are in good condition.

Columns (3), (4), (5), and (6) provide the estimation results of the fixed-effect models for health outcomes, after controlling for individuals' body mass index and smoking behavior. When comparing these coefficients with those reported in Tables IV and V, it is apparent that the inclusion of the life-style variables does not significantly affect the housing condition

20

results. For physical and mental health, the life-style variables do not make any difference for the housing condition effect, no matter whether the home is in need of a partial or a full renovation. For doctor visits, the housing condition coefficients changes, but they seem to get stronger, rather than weaker. However, this may also be caused by a sampling effect – we can include the lifestyle controls into the regressions on bad health and doctor visits for just a quarter of the observations. For sick leave, we document no statistically significant effect. These results provide some indication that the evidence in Tables IV through VI are not likely to be caused by lifestyle choices that affect both housing and health investments.

[Table VII]

Non-parametric event studies

In this subsection we present the results of an event study based on home renovations of the dwellings of individuals in our sample. This method has been recently used by studies in economics to provide quasi-experimental evaluations of the impact associated with hospital admissions for families (Dobkin et al., 2018) or the effect of public spending on schools on academic performance (Lafortune et al., 2018). We use home renovations as an exogenous, major trigger of changes in housing conditions. This strategy helps to separate the impact of home conditions on health outcomes from other potential secular trends, and from the potential endogeneity of reported housing conditions on health status. In particular, we analyze the coefficients associated with various year indicators describing the changes in health conditions of respondents in the years before and after the renovation event.

The non-parametric event study specification takes the following form:

$$DoctorVisits_{i,d,t} = \sum_{r=-4}^{-2} \mu_r + \sum_{r=0}^{3} \mu_r + \lambda X_{i,t} + \delta Z_{d,t} + \alpha_i + t_t + \epsilon_{i,d,t} \qquad (2)$$

where $DoctorVisits_{i,d,t}$ describes the number of doctor visits of individual i, living in dwelling d in year t; μ_r are the key coefficients; they describe the changes in visits to the doctor ($DoctorVisits_{i,d,t}$) relative to the omitted time category, μ_{-1}, year before the renovation. The rest of variables and fixed-effects in the event study are the same as in our main specification (Equation 1).

21

We use the non-parametric event study to examine trends in doctor visits around the renovation event. Figure III displays the changes in doctor visits before and after the renovation event. For this robustness check, the sample is restricted to tenants. As discussed in the methodology section, for tenants the decision to renovate a home is made by a landlord, and is as such exogenous to the tenant's health.

Panel (a) describes the changes in doctor visits before an after a renovation of the house. Panel (a) includes all types of home renovations, while restricting the sample to renovations paid for by the landlord (N= 4,238). We compute the year that the renovation took place in a dwelling based on a dummy variable that takes the value of one when there is any renovation work. In Panel (b) we present the results of renovations of heating systems (N= 1,289), and in Panel (c) we display the effect of window renovations (N=2,692).

In all three figures we observe no indication of pretrends: none of the coefficients of the year indicators preceding the renovations is significantly different from zero. Importantly, we observe a significant drop in doctor visits following home renovations, with the coefficients indicating a decrease in doctor visits of -0.225 (year t+1) to -0.284 (year t+3). This corresponds to a decrease of 8 percent and 10 percent in the average number of doctor visits in the estimation sample ($\mu = 2.90$), respectively.

The results presented in this subsection indicate the lack of secular trends leading to the renovation event, and show that exogenous renovation shocks significantly reduce doctor visits in a similar magnitude to the effects described in the main result section of the paper, corroborating the findings on home conditions and health outcomes.

[Figure III]

5.5 *Housing Conditions and Avoidance Behavior*

The literature shows that individuals do not necessarily remain passive towards the hazards in their living environments. Agents tend to take multiple actions to avoid or reduce their exposure to health-detrimental environmental conditions. Evidence from the housing market shows that households are willing to pay a premium to live in neighborhoods with cleaner air, or to stay away from sources of air pollution such as toxic plants (see, for ex-

ample, Chay and Greenstone, 2005; Currie et al., 2015). In addition, individuals exchange outdoor leisure for indoor leisure in order to reduce their exposure to negative external conditions, spending more time indoors in highly polluted areas or on extremely hot days (Neidell, 2009; Graff Zivin and Neidell, 2014). Similarly, studies on lead paint remediation programs provide evidence of avoidance behavior relative to sources of indoor pollution. Individuals are willing to pay a rent or price premium to be in houses that are certified to be lead-free (Billings and Schnepel, 2017).

We explore different behavioral reactions aimed at avoiding the exposure to (poor) housing conditions. In essence, agents have two main ways to change their exposure to poor housing conditions: either through moving or through renovation. In this part of the paper, we explore how poor housing conditions affect the likelihood of either of these two actions, distinguishing between home owners and tenants.

Table VIIIA presents the estimation results. Columns (1) and (2) provide the estimates of the link between poor housing conditions and the probability of moving, with column (1) documenting the results for tenants and column (2) documenting the results for home owners. The estimates indicate that individuals in our sample indeed seem to avoid poor housing conditions by moving to a different address. Both tenants and homeowners are more likely to move in the year after reporting that their home is in need of partial or major renovation, with the likelihood of moving increasing with more detrimental housing conditions. Interestingly, the effects are almost comparable for tenants and home owners – both groups are about 1 percent more likely to move if their home needs partial renovation and are 3 percent more likely to move if it needs a major renovation. This result suggests that tenants and home owners equally dislike living in a poorly maintained home, and "vote with their feet" in a similar manner.

The other possible response to adverse housing conditions is renovating the home. Here, we find very different results. For both tenants and home owners we observe an increased likelihood of renovation following poor housing conditions, but the extent of the effect differs substantially across the two groups. Columns (3) and (4) show estimation results for tenants, distinguishing between renovations paid by the tenant and paid by the landlord. The estimation results in column (3) indicate that tenants tend not to renovate their dwelling

after they start reporting problems with the housing conditions. Landlords, however, show a higher propensity to renovate the dwellings they own when their tenants report problems with the housing conditions: the likelihood of a renovation is 3 percent higher when a partial renovation is needed, and 4.7 percent higher when a major renovation is required. But this effect is trumped by the effects observed for home owners, who are 7.4 more likely to renovate their home after reporting the need for a partial renovation, and are 22.6 percent more likely to renovate in case of the need for a major renovation.

These results point at a split incentive or external effects problem, where the agent making the investment decision is not the direct beneficiary of the investment outcomes. Home owners reap the full benefit of their renovation investments, both in increased house value (see for instance Billings and Schnepel, 2017) and in improved health and comfort. Landlords, on the other hand, only receive the benefit of increased home values following renovations, while the health benefits affect the tenants only. And if tenants would pay for the renovation, they would receive the health and comfort benefits, while their landlord would receive the increase in home value.

Standard economic theory predicts underinvestment in the latter two cases, which is aligned with the results presented in Table VIIIA. Although tenants and homeowners similarly dislike living in poor housing conditions, as suggested by their comparable likelihood to move, tenants are much more likely to face prolonged exposure to such conditions. In Table VIIIB we provide evidence of this, showing that tenants spend 1.3 years longer in a house that needs a renovation than homeowners, thereby suffering longer from adverse indoor environmental conditions.

[Table VIII]

6 CONCLUSION

The predicted rise in healthcare spending is a major concern for developed economies. Environmental conditions have been shown to significantly affect public health outcomes, and over the past decades, public policy has addressed issues ranging from curbing CO_2

emissions to reducing the detrimental effects of heat waves (see Deschenes, 2014; Graff Zivin and Neidell, 2013). However, it is estimated that in developed economies, individuals spend more than 90 percent of their time indoors. Understanding the effect of indoor conditions on health outcomes is thus critical, for policymakers, private market participants, and academia alike.

This study explores whether and how the condition of homes affect the health of their inhabitants. The limited number of existing studies on the topic of housing conditions and health outcomes either fail to establish causality, or address housing conditions in poor areas, often in slums or developing countries, making the results hard to generalize to developed economies.

Using a long-running household panel dataset, the German Socioeconomic Panel (GSOEP), this paper attempts to identify a causal link between housing conditions and health outcomes. The sample includes more than 300,000 respondent/year observations for the period between 1992 and 2014, allowing for monitoring of the health outcomes of the same individual, exposed to varying housing conditions, over the sample period. Our empirical specification exploits the changes in health outcomes associated with within-individual variation in housing conditions, and focuses specifically on tenants, for whom home renovation is exogenous to health outcomes.

The results provide evidence that residents of poorly maintained dwellings report a lower subjective health status and visit the doctor 11 percent more often. An event study around home renovation corroborates these findings. Regarding doctor visits, we do not find a significant effect on the likelihood of visiting the doctor in the first place (the intensive margin), but once individuals go to the doctor, they go significantly more often when they live in a dwelling in need of renovation (the extensive margin). Regarding sick leave, we find some evidence on the salience of housing conditions, but not in the most extensive model.

These effects are stronger for dwellings that are in need of a major renovation rather than a partial renovation. The results hold across income groups, and for both owner-occupiers and tenants. Given that results remain robust after controlling for lifestyle indicators such as body mass index and smoking, we conclude that the documented effects are not caused

by common underlying lifestyle choices, but that the causality runs from housing conditions to health outcomes.

We also investigate heterogeneity by gender and age cohorts. For gender, we find no difference in the documented effects, but the results appear to be determined mostly by the older age cohorts. For the age cohort under 31 years, we find no significant relationship between housing conditions and health, while that relationship materializes for the older age cohorts, and is especially strong for those aged 64 and over. For the latter, we document 6 percent more visits to the doctor when a home is in need of a partial renovation, increasing to 20 percent when the home is in need of a major renovation. This may explain the absence of effects for sick leave as compared to doctor visits: those individuals with an age of 64 and older tend not to work, so do not report sick for work, even if they are ill and have to go to the doctor.

Finally, we analyze avoidance behavior, by investigating the likelihood of moving and renovation when respondents report poor housing conditions. We find that tenants and homeowners are equally likely to move in the year after reporting poor housing conditions, suggesting that they equally dislike poor housing conditions. However, we also document that homeowners are almost 23 percent more likely to renovate their home under these circumstances, while that percentage is much lower for tenants, no matter whether they or their landlord pay for the renovation. This finding suggests underinvestment in home renovation in the rental market, resulting in prolonged exposure to an adverse indoor environment, likely leading to reduced health outcomes.

The results of this paper indicate that the condition of individuals' homes affects their health in a statistically and economically significant manner, especially when these individuals 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. Even though the medical care system in Germany is socialized, and the housing market lacks transparency (Germany does not maintain publicly available property records), we can do a simple back-of-the-envelope welfare analysis.

The GSOEP survey is representative for Germany, and we thus infer that 29 percent of German homes need some form of renovation. Based on the findings in this paper,

improving the maintenance status for homes that need renovation would reduce visits to the doctor by 11 percent. In Germany, the cost of doctor visits is difficult to calculate, given the fact that healthcare is socialized, we therefore make inferences based on total healthcare spending, assuming that doctor visits lead to follow-up procedures, and the increase in doctor visits is thus a good indication for a possible increase in overall healthcare spending.

The 2017 healthcare spending in Germany was EUR 374.2 billion – assuming that healthcare spending is equally distributed across households and homes (arguable, this is a heroic assumption), reducing healthcare spending for 29 percent of households by 11 percent would lead to annual savings on healthcare costs of EUR 11.9 billion. Assuming perpetuity, no growth in healthcare costs, and a cost of capital of 2 percent, the annual healthcare savings would translate into a present value of EUR 594 billion.

To achieve these savings, German landlords would have to invest significantly into their investment properties, and homeowners would have to improve the quality of their homes. The current housing stock in Germany consists of some 41 million homes and apartment units, of which about 50 percent are apartments (20.8 million units in 3.1 million apartment buildings). Data on the cost of renovations is not available systematically, but assuming an investment of EUR 50,000 to significantly improve the maintenance status of a home (25 percent of the cost of an average home) and an investment of EUR 25,000 to improve the quality of an apartment unit (there are economies of scale to be achieved in apartment buildings, given the extent of shared walls and shared services), the aggregate cost of upgrading the 29 percent of the building stock with deficiencies in maintenance would be EUR 444 billion.

This simple calculation suggests that the net present value of future savings on healthcare costs far outweighs the costs of upgrading the building stock. This example ignores co-benefits from improving the building stock, such as reduced energy consumption, increased comfort, and the subsequent private benefits of increasing house prices, which would accrue to landlords and homeowners..

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, mak-

ing the relevance of the building stock for health outcomes ever more important. Public policy measures aimed at maintaining and improving the condition of the building stock could have tangible effects on prevention of disease, thereby reducing the burden on the healthcare system and its finances.

References

Adams, P., M. Hurd, D. McFadden, A. Merrill, and T. Ribeiro (2003). Healthy, wealthy, and wise? Tests for direct causal paths between health and socioeconomic status. *Journal of Econometrics 112*(1), 3–56.

Andersen, H., A. Mühlbacher, M. Nübling, J. Schupp, and G. Wagner (2007). Computation of standard values for physical and mental health scale scores using the SOEP version of SF12v2. *Journal of Applied Social Science Studies (Schmollers Jahrbuch) 127*(1), 171–182.

Barreca, A. I. (2012). Climate change, humidity, and mortality in the United States. *Journal of Environmental Economics and Management 63*(1), 19–34.

Barron, M. and M. Torero (2017). Household electrification and indoor air pollution. *Journal of Environmental Economics and Management 86*, 81–92.

Bilger, M. and V. Carrieri (2013). Health in the cities: When the neighborhood matters more than income. *Journal of Health Economics 32*(1), 1–11.

Billings, S. B. and K. T. Schnepel (2017). The value of a healthy home: Lead paint remediation and housing values. *Journal of Public Economics 153*, 69–81.

Bind, M., A. Peters, P. Koutrakis, B. Coull, P. Vokonas, and J. Schwartz (2016). Quantile regression analysis of the distributional effects of air pollution on blood pressure, heart rate variability, blood lipids, and biomarkers of inflammation in elderly american men: The normative aging study. *Environmental Health Perspectives 124*(8), 1189–1198.

Cattaneo, M. D., S. Galiani, P. J. Gertler, and S. Martinez (2009). Housing, health, and happiness. *American Economic Journal: Economic Policy 1*(1), 75–105.

Chay, K. Y. and M. Greenstone (2005). Does air quality matter? Evidence from the housing market. *Journal of Political Economy 113*(2), 376–424.

Contoyannis, P., A. M. Jones, and N. Rice (2004). The dynamics of health in the British Household Panel Survey. *Journal of Applied Econometrics 19*(4), 473–503.

Currie, J. (2009). Healthy, wealthy, and wise: Socioeconomic status, poor health in childhood, and human capital development. *Journal of Economic Literature 47*(1), 87–122.

Currie, J., L. Davis, M. Greenstone, and R. Walker (2015). Environmental health risks and housing values: Evidence from 1,600 toxic plant openings and closings. *American Economic Review 105*(2), 678–709.

Currie, J., E. A. Hanushek, E. M. Kahn, M. Neidell, and S. G. Rivkin (2009). Does pollution increase school absences? *Review of Economics and Statistics 91*(4), 682–694.

Currie, J. and M. Neidell (2005). Air pollution and infant health: What can we learn from california's recent experience? *Quarterly Journal of Economics 120*(3), 1003–1030.

Cutler, D. and E. Glaeser (2005). What explains differences in smoking, drinking, and other behaviors? *American Economic Review 95*(2), 238–242.

Deschenes, O. (2014). Temperature, human health, and adaptation: A review of the empirical literature. *Energy Economics 46*, 606–619.

Deschênes, O. and M. Greenstone (2011). Climate change, mortality, and adaptation: Evidence from annual fluctuations in weather in the US. *American Economic Journal: Applied Economics 3*(4), 152–185.

Dieleman, J., M. Campbell, A. Chapin, E. Eldrenkamp, V. Fan, A. Haakenstad, Z. Kates, J., Li, T. Matyasz, A. Micah, and A. Reynolds (2017). Future and potential spending on health 2015-40: Development assistance for health, and government, prepaid private, and out-of-pocket health spending in 184 countries. *The Lancet 389*(10083), 2005–2030.

Dobkin, B. C., A. Finkelstein, R. Kluender, and M. J. Notowidigdo (2018). The Economic Consequences of Hospital Admissions. *American Economic Review 108*(2), 308–352.

Ebenstein, A., M. Fan, M. Greenstone, G. He, and M. Zhou (2017). New Evidence on the Impact of Sustained Exposure to Air Pollution on Life Expectancy from China's Huai. *Proceedings of the National Academy of Sciences*.

Eibich, P. (2015). Understanding the effect of retirement on health: Mechanisms and heterogeneity. *Journal of Health Economics 43*, 1–12.

Frijters, P., J. P. Haisken-DeNew, and M. A. Shields (2005). The causal effect of income on health: Evidence from German reunification. *Journal of Health Economics 24*(5), 997–1017.

Galiani, S., P. J. Gertler, R. Undurraga, R. Cooper, S. Martínez, and A. Ross (2017). Shelter from the storm: Upgrading housing infrastructure in Latin American slums. *Journal of Urban Economics 98*, 187–213.

Goebel, J. (2017). SOEP Core v32. Documentation on biography and life history data. *SOEP Survey Papers 418*.

Graff Zivin, J. and M. Neidell (2013). Environment, health, and human capital. *Journal of Economic Literature 51*(2012), 689–730.

Graff Zivin, J. and M. Neidell (2014). Temperature and the allocation of time: Implications for climate change. *Journal of Labor Economics 32*(1), 1–26.

Grossman, M. (1972). On the concept of health capital and the demand for health. *Journal of Political Economy 80*(2), 223–255.

Hanna, R., E. Duflo, and M. Greenstone (2016). Up in smoke The influence of household behavior on the long-run impact of improved cooking stoves. *American Economic Journal: Economic Policy 8*(1), 80–114.

Hanna, R. and P. Oliva (2015). The effect of pollution on labor supply: Evidence from a natural experiment in Mexico City. *Journal of Public Economics 122*, 68–79.

Imelda (2018). Indoor air pollution and infant mortality: A new approach. *American Economic Association Papers and Proceedings 108*, 416–21.

Klepeis, N. E., W. C. Nelson, W. R. Ott, J. P. Robinson, a. M. Tsang, P. Switzer, J. V. Behar, S. C. Hern, and W. H. Engelmann (2001). The National Human Activity Pattern

Survey (NHAPS): A resource for assessing exposure to environmental pollutants. *Journal of Exposure Analysis and Environmental Epidemiology 11*(3), 231–252.

Kuenn, S. and J. Palacios (2017). The Impact of housing quality on health and labor market outcomes.

Künn-Nelen, A. (2016). Does commuting affect health? *Health Economics 25*(8), 984–1004.

Lafortune, J., J. Rothstein, and D. W. Schanzenbach (2018). School Finance Reform and the Distribution of Student Achievement. *10*(w22011), 1–26.

Ludwig, J., G. J. Duncan, L. A. Gennetian, L. F. Katz, R. C. Kessler, J. R. Kling, and L. Sanbonmatsu (2012). Neighborhood effects on the long-term well-being of low income adults. *Science 337*, 1505–1510.

Luechinger, S. (2009). Valuing air quality using the life satisfaction approach. *The Economic Journal 119*(536), 482–515.

Marcus, J. (2013). The effect of unemployment on the mental health of spouses - Evidence from plant closures in Germany. *Journal of Health Economics 32*(3), 546–558.

Neidell, M. (2009). Information, avoidance behavior, and health. The effect of ozone on asthma hospitalizations. *The Journal of Human Resources 44*(3), 450–478.

Pohlmeier, W. and V. Ulrich (1995). An econometric model of the two-part decisionmaking process in the demand for health care. *The Journal of Human Resources 30*(2), 339.

Pollack, C. E., K. O. Von dem, and J. Siegrist (2004). Housing and health in Germany. *Journal of Epidemiology and Community Health 58*(3), 216–222.

Reinhold, S. and H. Jürges (2010). Secondary school fees and the causal effect of schooling on health behavior. *Health Economics 19*(8), 994–1001.

Rosen, G. (2015). *A history of public health*. JHU Press.

Santos Silva, J. M. and F. Windmeijer (2001). Two-part multiple spell models for health care demand. *Journal of Econometrics 104*(1), 67–89.

Schiele, V. and H. Schmitz (2016). Quantile treatment effects of job loss on health. *Journal of Health Economics 49*, 59–69.

Schlenker, W. and W. R. Walker (2016). Airports, air pollution, and contemporaneous health. *Review of Economic Studies 83*(2), 768–809.

Shaw, M. (2004). Housing and public health. *Annual Review of Public Health 25*, 397–418.

Smith-Sivertsen, T., E. Díaz, D. Pope, R. T. Lie, A. Díaz, J. McCracken, P. Bakke, B. Arana, K. R. Smith, and N. Bruce (2009). Effect of reducing indoor air pollution on women's respiratory symptoms and lung function: The RESPIRE Randomized Trial, Guatemala. *American Journal of Epidemiology 170*(2), 211–220.

Thomson, H., S. Thomas, E. Sellstrom, and M. Petticrew (2009). The health impacts of housing improvement: a systematic review of intervention studies from 1887 to 2007. *American Journal of Public Health 99*(3), S681–S692.

Wagner, G., J. Frick, and J. Schupp (2007). The german socio-economic panel study (SOEP) - scope, evolution and enhancements. *Journal of Applied Social Science Studies 127*(1), 139–169.

WHO (2007). Large analysis and review of European housing and health Status (LARES). Technical report.

Winkelmann, R. (2004). Health care reform and the number of doctor visits - An econometric analysis. *Journal of Applied Econometrics 19*(4), 455–472.

Figure I
Housing conditions and occupant health
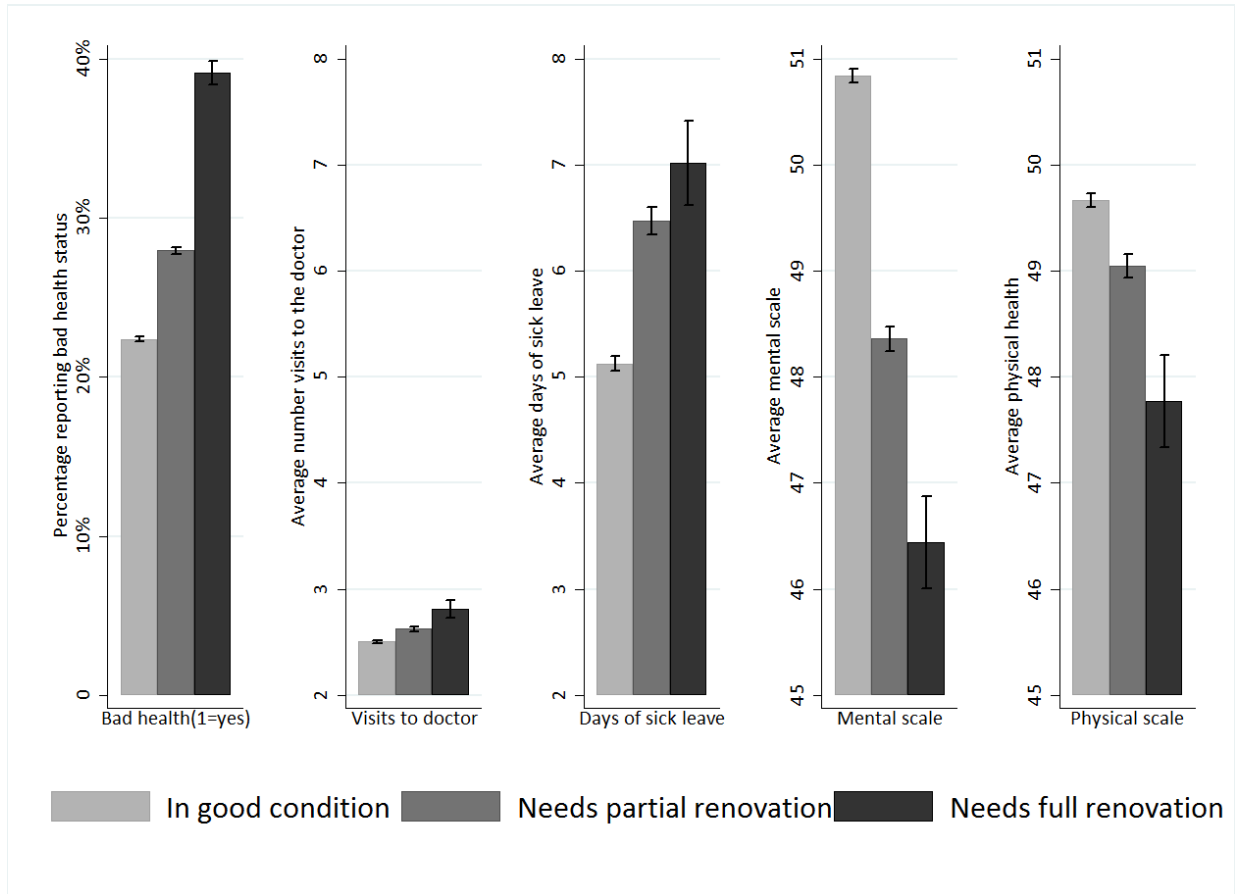
Notes: Figure I presents the average level of health measures for different housing conditions as well as the 95 percent confidence interval. Current health ranges from 1 (very good health) to 5 (bad health). The three measures are available for all years in our sample (1990-2014). Mental and physical scales range from 0 to 100 (available for survey waves 2002, 2004, 2006, 2008, 2010, 2012 and 2014).

Figure II
Housing conditions and occupant mental and physical health over lifetime
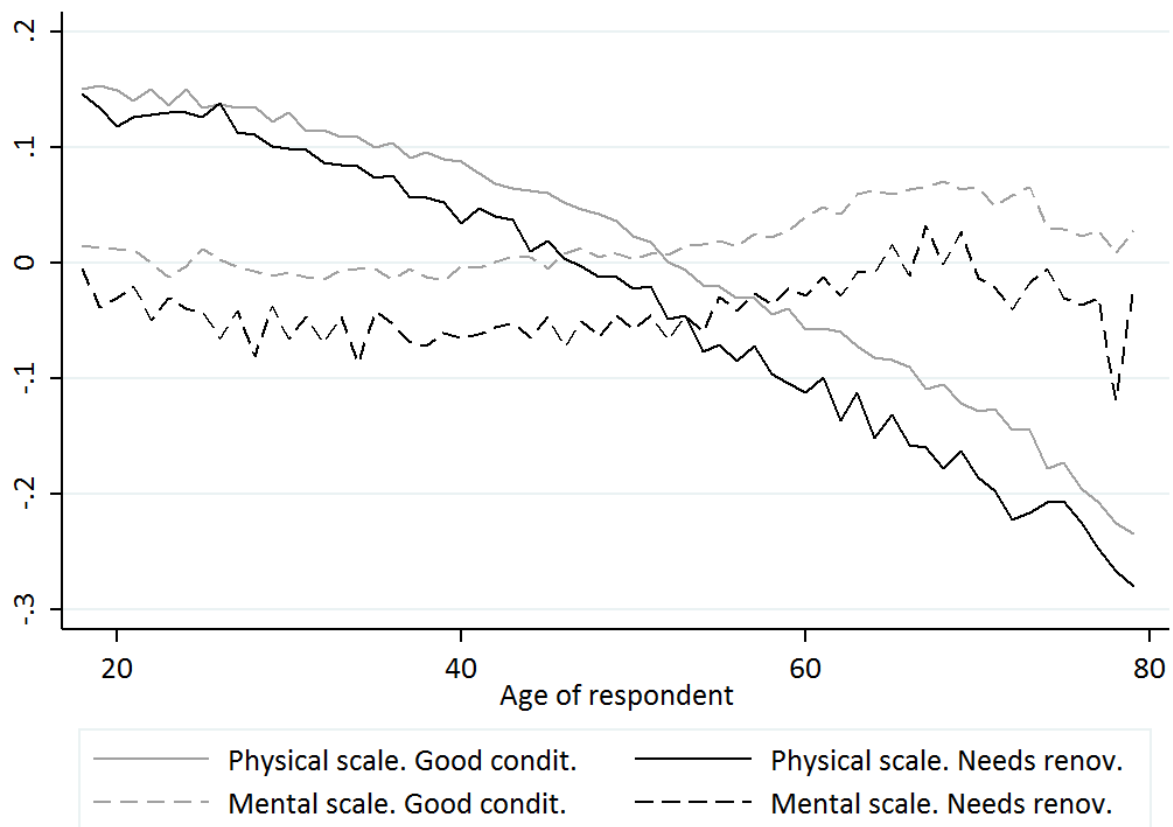
Notes: Figure II shows the standardized conditional mean of physical and mental scales for the sample of individuals that report living in a house in good conditions and those report living in a house in need of repairs, over the lifetime of an individual. The conditional mean is constructed from the regression controlling for gender, income, eduation and marital status. Mental and physical scales range from 0 to 100 (available for survey waves 2002, 2004, 2006, 2008, 2010, 2012 and 2014).

Table I
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
Bad/Poor health (1=yes)	0.25	0.43
Visits to the doctor during the last three months	2.60	4.30
Number of days out sick (per year)	5.51	20.76
Dwelling Characteristics		
Housing condition		
In 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 in bad condition	3.69	4.75
Size (in m^2)	106.12	47.02
Number of rooms larger than 6 m^2	4.2	1.91
Construction year	1969	24.39
Amount of rent minus heating costs (monthly, in euros)	467.82	238
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). The summary statistics displayed above consider the full sample period (from 1990 to 2014), and include 357,353 observations (and 57,581 individuals).

Table II
Household and dwelling characteristics per dwelling condition

	(1) Dwelling in good conditions	(2) Dwelling in need of minor renovation	(3) Dwelling in need of major renovation
Monthly household income (in euros)	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
Dwelling size (in m^2)	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 Family house	0.37	0.29	0.19
1-2 Family rowhouse	0.20	0.16	0.11
Apt. in 3-4 unit bldg.	0.10	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 II reports the descriptive statistics separated for different housing conditions. Standard deviations are reported in parentheses. Information on "Value dwelling" is only available for 2002, 2007 and 2012.

Table III
Housing conditions and health outcomes

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

	Household Net Income				Respondent Age				Tenancy Status	
	1st quartile (low)	2nd quartile	3rd quartile	4th quartile (high)	1st quartile (young)	2nd quartile	3rd quartile	4th quartile (old)	Owner occupied	Rental home
In good condition	0.27	0.20	0.16	0.12	0.12	0.12	0.19	0.29	0.17	0.20
Needs partial renovation	0.29	0.22	0.19	0.15	0.14	0.16	0.26	0.38	0.21	0.23
Needs full renovation	0.33	0.28	0.20	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 (low)	2nd quartile	3rd quartile	4th quartile (high)	1st quartile (young)	2nd quartile	3rd quartile	4th quartile (old)	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 (low)	2nd quartile	3rd quartile	4th quartile (high)	1st quartile (young)	2nd quartile	3rd quartile	4th quartile (old)	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 III (continued)

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 (low)	2nd quartile	3rd quartile	4th quartile (high)	1st quartile (young)	2nd quartile	3rd quartile	4th quartile (old)	Owner occupied	Rental home
In good condition	3.07	2.67	2.41	2.18	1.82	2.01	2.6	3.58	2.46	2.64
Needs partial renovation	3.05	2.70	2.55	2.42	1.97	2.24	3.01	4.00	2.63	2.76
Needs full renovation	3.38	2.88	2.76	2.16	2.10	2.44	3.47	4.94	3.22	2.97

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

	Household Net Income				Respondent Age				Tenancy Status	
	1st quartile (low)	2nd quartile	3rd quartile	4th quartile (high)	1st quartile (young)	2nd quartile	3rd quartile	4th quartile (old)	Owner occupied	Rental home
In good condition	4.70	5.53	5.78	4.68	4.69	6.06	8.42	1.68	4.49	5.92
Needs partial renovation	5.92	6.8	7.16	5.82	5.49	7.45	9.82	2.26	5.64	6.85
Needs full renovation	6.66	7.62	8.31	5.77	5.4	9.28	9.86	2.87	5.29	7.41

Table IV: Estimation results housing conditions on subjective health status

	(1) Bad Health (1=Yes)	(2) Bad Health (1=Yes)	(3) Bad Health (1=Yes)	(4) Log of Physical Health	(5) Log of Physical Health	(6) Log of Physical Health	(7) Log of Mental Health	(8) Log of Mental Health	(9) Log of Mental Health
Housing condition									
Needs partial renovation (1=Yes)	0.023***	0.011***	0.007**	-0.018***	-0.008***	-0.004	-0.033***	-0.017***	-0.017***
	[0.002]	[0.002]	[0.003]	[0.002]	[0.002]	[0.003]	[0.002]	[0.003]	[0.004]
Needs major renovation (1=Yes)	0.048***	0.027***	0.019***	-0.038***	-0.023***	-0.018*	-0.073***	-0.036***	-0.040***
	[0.005]	[0.006]	[0.007]	[0.006]	[0.008]	[0.010]	[0.008]	[0.011]	[0.013]
Age of respondent	-0.000	-0.049***	-0.049***	-0.003***	0.002*	0.001	0.000	0.005***	0.002
	[0.000]	[0.001]	[0.002]	[0.000]	[0.001]	[0.002]	[0.000]	[0.001]	[0.002]
Log of monthly income	-0.037***	-0.014***	-0.022***	0.025***	0.003	0.008	0.034***	0.018***	0.028***
	[0.002]	[0.003]	[0.005]	[0.002]	[0.003]	[0.005]	[0.003]	[0.004]	[0.007]
Individual is working (1=Yes)	-0.031***	-0.008***	-0.014***	0.024***	0.007***	0.008*	0.007***	0.002	0.021***
	[0.002]	[0.003]	[0.004]	[0.002]	[0.003]	[0.005]	[0.003]	[0.003]	[0.006]
Years of education	-0.008***	-0.000	-0.000	0.009***	-0.003	0.001	-0.001	0.000	0.010
	[0.001]	[0.002]	[0.003]	[0.001]	[0.002]	[0.004]	[0.001]	[0.003]	[0.007]
Number of observations	298,675	298,675	143,837	81,612	81,612	35,176	81,611	81,611	35,175
Number of individuals	67,589	67,589	41,404	33,779	33,779	17,626	33,779	33,779	17,626
Mean dependent var.	0.236	0.236	0.261	3.882	3.882	3.884	3.895	3.895	3.877
Year-fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Socio-demographic controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Individual-fixed effects	NO	YES	YES	NO	YES	YES	NO	YES	YES
Dwelling-fixed effects	NO	YES	YES	NO	YES	YES	NO	YES	YES
Sample restrict. tenants	NO	NO	YES	NO	NO	YES	NO	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

40

Table V
Estimation results housing condition and demand for health care

	(1) Visit Doctor (1 = Yes)	(2) Visit Doctor (1 = Yes)	(3) Visit Doctor (1 = Yes)	(4) Visits Doctor (Number)	(5) Visits Doctor (Number)	(6) Visits Doctor (Number)	(7) Days on Sick Leave	(8) Days on Sick Leave	(9) Days on Sick Leave
Housing condition									
Needs partial renovation (1=Yes)	-0.015*** [0.003]	-0.002 [0.003]	0.002 [0.004]	0.223*** [0.031]	0.060** [0.030]	0.050 [0.044]	0.916*** [0.129]	0.125 [0.162]	0.172 [0.215]
Needs major renovation (1=Yes)	-0.010 [0.009]	-0.007 [0.008]	-0.003 [0.010]	0.452*** [0.121]	0.293*** [0.095]	0.228** [0.110]	1.387*** [0.389]	0.205 [0.464]	0.000 [0.556]
Age of respondent	-0.001** [0.000]	0.007*** [0.001]	0.006*** [0.002]	0.049*** [0.006]	-0.042*** [0.012]	-0.036* [0.020]	0.503*** [0.018]	0.228*** [0.054]	0.191** [0.089]
Log of monthly income	-0.002 [0.004]	0.007* [0.004]	0.009 [0.006]	-0.142*** [0.040]	-0.117*** [0.043]	-0.054 [0.065]	-0.197 [0.128]	0.180 [0.218]	-0.073 [0.355]
Individual is working (1=Yes)	0.047*** [0.003]	0.023*** [0.003]	0.017*** [0.005]	-0.775*** [0.040]	-0.332*** [0.040]	-0.383*** [0.061]	4.460*** [0.137]	2.177*** [0.259]	1.967*** [0.401]
Years of education	-0.006*** [0.001]	-0.001 [0.002]	-0.001 [0.003]	0.004 [0.010]	0.009 [0.021]	0.013 [0.033]	-0.302*** [0.036]	-0.002 [0.101]	-0.059 [0.158]
Observations	279,700	279,700	132,227	272,130	272,130	127,710	276,653	276,653	131,143
Mean dependent var.	0.309	0.309	0.309	2.612	2.612	2.612	5.490	5.490	5.490
Number of individuals	62,734	62,734	37,662	62,281	62,281	37,275	65,740	65,740	39,995
Year-fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Socio-demographic controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Individual-fixed effects	NO	YES	YES	NO	YES	YES	NO	YES	YES
Dwelling-fixed effects	NO	YES	YES	NO	YES	YES	NO	YES	YES
Sample restrict. tenants	NO	NO	YES	NO	NO	YES	NO	NO	YES

Table VI
Heterogeneous effects by age group

Panel A. Visits to the doctor

	(1) Doctor visits Age 18-30	(2) Doctor Visits Age 31-40	(3) Doctor Visits Age 41-50	(4) Doctor Visits Age 51-63	(5) Doctor Visits Age > 64
Needs partial renovation	-0.123	0.043	0.018	0.146	0.240***
(1=Yes)	[0.088]	[0.103]	[0.088]	[0.100]	[0.091]
Needs for major renovation	0.102	0.524*	0.567*	0.468	0.766**
(1=Yes)	[0.276]	[0.316]	[0.315]	[0.355]	[0.329]
Number of observations	27,533	34,838	36,887	41,911	46,594
Number of individuals	14,302	15,001	13,738	12,046	10,212
Mean dependent var.	1.863	2.051	2.247	3.111	3.830
Individual-fixed effects	YES	YES	YES	YES	YES
Dwelling-fixed effects	YES	YES	YES	YES	YES
Year-fixed effects	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

Panel B. Days on sick leave

	(1) Days on Sick Leave Age 18-30	(2) Days on Sick Leave Age 31-40	(3) Days on Sick Leave Age 41-50	(4) Days on Sick Leave Age 51-63	(5) Days on Sick Leave Age > 64
Needs partial renovation	0.122	0.088	1.344**	-0.812	-0.043
(1=Yes)	[0.414]	[0.559]	[0.638]	[0.718]	[0.155]
Needs major renovation	-1.007	1.414	1.747	-1.390	-0.235
(1=Yes)	[1.927]	[1.495]	[1.687]	[1.890]	[0.214]
Number of observations	29,623	36,933	38,280	42,886	47,031
Number of Individuals	15,654	16,442	14,627	12,510	10,287
Mean dependent var.	4.849	6.143	7.393	8.515	0.571
Individual-fixed effects	YES	YES	YES	YES	YES
Dwelling-fixed effects	YES	YES	YES	YES	YES
Year-fixed effects	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 VII
Estimation results housing condition and health behavior

|	(1) Body Mass Index	(2) Smoke (1=Yes)	(3) Log of Physical Scale	(4) Log of Mental Scale	(5) Doctor Visits	(6) Days on Sick Leave
Needs partial renovation (1 = yes)	0.012	-0.001	-0.009***	-0.018***	0.223***	0.355
	[0.027]	[0.005]	[0.003]	[0.003]	[0.063]	[0.359]
Needs major renovation (1 = yes)	-0.018	-0.004	-0.017**	-0.040***	0.796***	-0.344
	[0.089]	[0.011]	[0.008]	[0.011]	[0.184]	[1.155]
Observations	83,223	70,334	68,141	68,140	69,824	69,825
R-squared	0.056	0.024	0.033	0.009	0.004	0.003
Number of individual-dwellings	33,970	30,215	29,688	29,688	30,007	30,008
Mean dependent Variable	25.69	0.336	3.883	3.895	2.612	5.490
Individual-dwelling fixed effects	YES	YES	YES	YES	YES	YES
Health behavior controls	NO	NO	YES	YES	YES	YES
Socio-demographic controls	YES	YES	YES	YES	YES	YES
Year-fixed effects	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. Body Mass Index, mental and physical scales, and smoking are available for survey waves 2002, 2004, 2006, 2008, 2010, 2012 and 2014.*P<0.10. ** P<0.05. *** P<0.01.

Figure III. Impact of home renovations on number of visits to the doctor
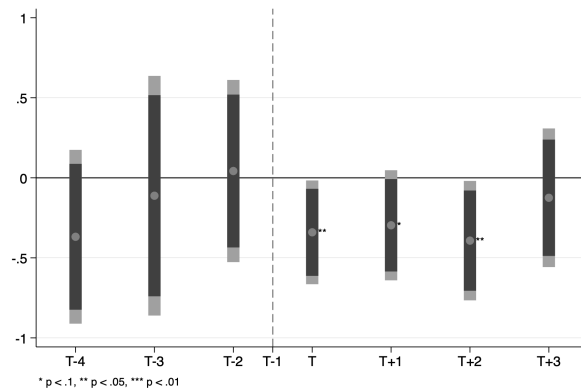
(a) Event study home renovations paid by landlord
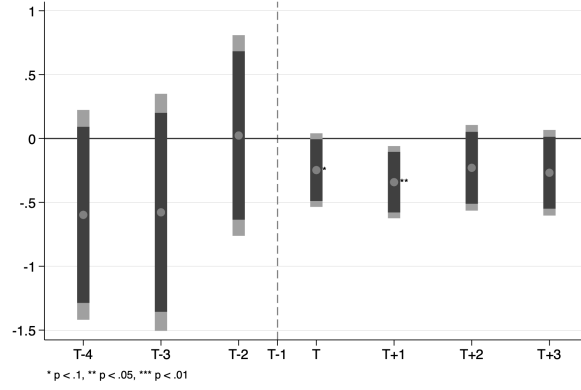
(b) Event study heating modernization paid by landlord
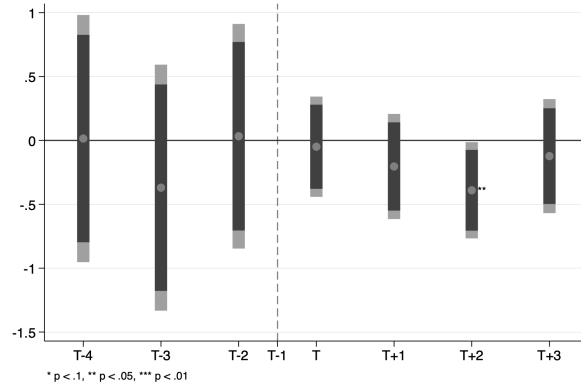
(c) Event study window modernization paid by landlord

Notes: The points represent the estimated effects of time indicators (i.e., the $\mu'_r s$ from the non-parametric event study (Eq. 2)). The dashed line describes the reference year ($r = -1$), the reminder coefficients represent changes in doctor visits with respect to μ_{-1}. The black (gray) bars show the 90% (95%) confidence intervals. The empirical model includes a full set of controls and fixed effects, as described in Equation 1. The standard errors are clustered at the household level. The sample is restricted to tenants in all regressions.

Table VIII

Panel A. Avoidance behavior to deficient housing condition

	(1)	(2)	(3)	(4)	(5)
	Move t (1=yes)		Renovation in Dwelling t (1=yes)		
	Tenant	Home-owner	Tenant (Self-Paid)	Tenant (Paid by Landlord)	Home-Owner
Needs partial renovation $t-1$	0.010***	0.012***	0.008***	0.030***	0.074***
	[0.002]	[0.002]	[0.002]	[0.003]	[0.007]
Needs major renovation $t-1$	0.034***	0.029***	0.005	0.047***	0.226***
	[0.005]	[0.009]	[0.005]	[0.008]	[0.026]
Observations	118,298	133,248	109,712	109,712	123,906
R-squared	0.033	0.013	0.004	0.005	0.010
Number of individuals	21,251	21,604	18,589	18,589	18,758
Mean dependent var.	0.0232	0.0232	0.039	0.144	0.199
Socio-demographic controls	YES	YES	YES	YES	YES
Year-fixed effects	YES	YES	YES	YES	YES
Individual-fixed effects	YES	YES	YES	YES	YES
Dwelling-fixed effects	NO	NO	YES	YES	YES

Notes: Coefficients from year fixed-effects, dwelling controls 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

Panel B. Years in need of renovation by ownership status

	(1)
	Years in need of renovation
Tenant (1=yes)	1.312***
	[0.105]
Observations	300,065
Socio-demographic controls	YES
Dwelling controls	YES
Year-fixed effects	YES

Notes: Coefficients from year fixed-effects, dwelling controls 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. The list of dwelling controls includes the size, number of rooms and year of construction in the apartment. The list of individual socio-economic controls include the monthly income, education years, whether the individual has a college degree, gender and age.

Table IX

Health status and avoidance behavior

	(1)	(2)	(3)	(4)	(5)
	Move$_t$ (1=yes)		Renovation in Dwelling$_t$ (1=yes)		
	Tenant	Home-owner	Tenant (Self-Paid)	Tenant (Paid by Landlord)	Home-Owner
Log of Physical Scale$_{t-1}$	-0.005	0.003	-0.016	-0.025	-0.024
	[0.008]	[0.003]	[0.010]	[0.018]	[0.018]
Log of Mental Scale$_{t-1}$	-0.011	-0.004	-0.001	-0.024	-0.029*
	[0.007]	[0.003]	[0.007]	[0.015]	[0.015]
Doctor Visits$_{t-1}$	-0.000	-0.000	0.000	0.000	0.001
	[0.000]	[0.000]	[0.000]	[0.001]	[0.001]
Observations	30,839	42,189	30,764	42,096	42,096
R-squared	0.030	0.009	0.005	0.005	0.005
Number of individuals	11,558	13,882	11,545	13,871	13,871
Mean dependent variable	0.0231	0.0231	0.122	0.122	0.144
Socio-demographic controls	YES	YES	YES	YES	YES
Year-fixed effects	YES	YES	YES	YES	YES
Individual-fixed effects	YES	YES	YES	YES	YES
Dwelling-fixed effects	NO	NO	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

46

Table AI
Home mantainance and health in rental sample

	(1) Renov. paid by landlord$_t$	(2) Renov. paid by landlord$_t$	(3) Renov. paid by landlord$_t$	(4) Renov. paid by landlord$_t$	(5) Renov. paid by landlord$_t$	(6) Renov. paid by landlord$_t$	(7) Renov. paid by landlord$_t$	(8) Renov. paid by landlord$_t$
Tenants bad health status (1=yes)$_{t-1}$	-0.004 [0.003]	-0.004 [0.003]						
Log tenant mental scale$_{t-1}$			-0.015 [0.010]	-0.015 [0.010]				
Log tenant physical scale$_{t-1}$					0.001 [0.013]	0.002 [0.013]		
Tenant doctor visits$_{t-1}$							0.000 [0.000]	0.000 [0.000]
Number of observations	106,885	106,499	29,374	29,293	29,375	29,294	98,185	97,854
Number of individuals	17,798	17,784	10,965	10,951	10,965	10,951	17,526	17,511
House conditions	NO	YES	NO	YES	NO	YES	NO	YES
Year-fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Individual-fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Socio-economic controls	YES	YES	YES	YES	YES	YES	YES	YES
Only tenants	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 Body Mass Index, mental and physical scales, and smoking are available for survey waves 2002, 2004, 2006, 2008, 2010, 2012 and 2014.