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The health effects of indoor housing conditions

An empirical study

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Abstract

In high-income countries healthcare expenditures are on the rise due to greying population and the scarcity of caregivers. By identifying the sources of variation in health one is able to identify proper solutions to dampen the economic burden of healthcare. This paper seeks to contribute to the existing but limited research on the relationship between housing conditions and health by analysing the potential causal relationship between housing conditions and occupant health. This is done by analysing a longitudinal dataset including 39,769 observations of individuals living in rental dwellings over a time-span of eighteen years. The analysis indicates that individuals living in poor housing conditions are more likely to report a higher number of health issues. Especially, this study finds that individuals living in a dwelling which is perceived to be 'too small' report on average 0.87 more doctor visits annually. This finding is perceived to be robust as the study at hand obtains similar results using a different dataset regarding children. These findings are economized in order to estimate the impact of poor housing conditions healthcare demand. The results show that the total number of additional doctor visits in Switzerland due to houses being 'too small' lies around 672,000 doctor visits annually.

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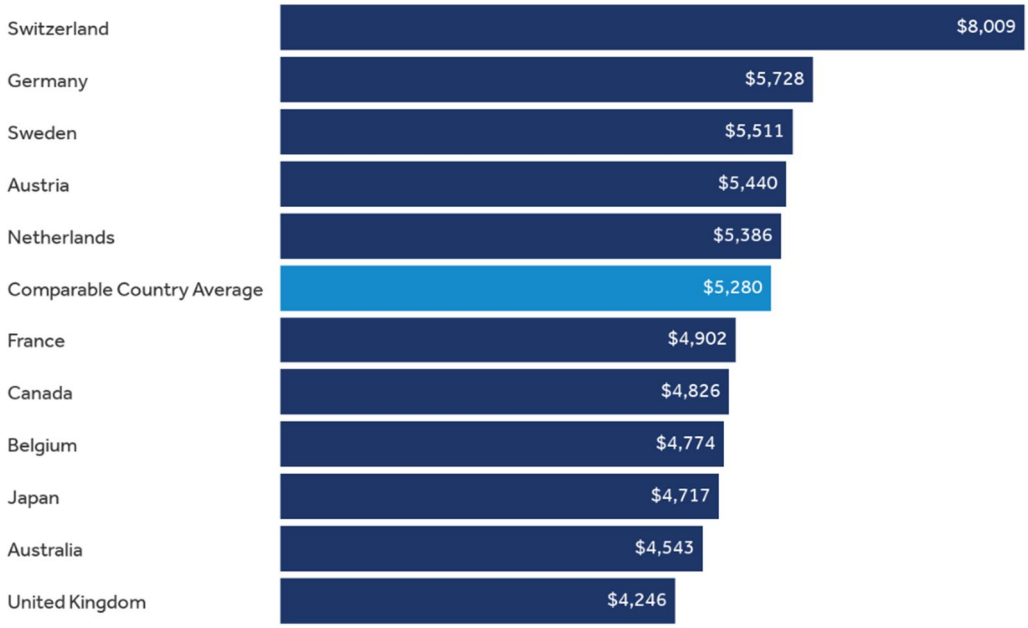
1. Introduction

It is no secret that a large chunk of the population in high-income countries referred to as 'Baby Boomers' (people born between 1945 and 1955) are ageing and demanding more healthcare. This phenomenon is putting a strain on healthcare services in these countries. The general expectation is that the ageing of populations is likely to characterize high-income countries such as Switzerland in the coming decades. According to the World Health Organization (2017), the proportion of individuals aged 65 and over is expected to rise from 18 percent in 2015 to over 26 percent in 2045 in Switzerland. In addition, life expectancy is increasing and the nation's elderly over the age of 100 are becoming more numerous every year. Next to the fact that the number of elderly grows, putting a strain on the healthcare system, the nonelderly population is decreasing, resulting in a severe shortage of direct caregivers. These projected trends are fundamental to the biggest problem in healthcare: Affordability.

The Swiss healthcare system has much in common with the system adopted by the Netherlands in 2006. According to Daley and Gubb (2013) both systems uphold the principles of universality and equality by mandating individuals to purchase health insurance on the private market and providing financial aid to lower income households. This results into increased availability of healthcare, higher quality and shorter waiting lists. This system has attracted the attention of a number of admirers, such as the United States. During Obama's presidency, the healthcare reforms were often classified as the "Swissifycation" of American healthcare.

Nevertheless, healthcare expenditures are on the rise in recent years due to greying population and the scarcity of caregivers. In Switzerland, health expenditures climbed to 11.4 percent of GDP over the last decade, 'basic package' premiums have increased by an average of five percent per year. The Swiss system has not been effective at containing costs and unsurprisingly there are now concerns that the premiums may become unaffordable (Daley & Gubb, 2013).

Figure 1. Healthcare expenditures per capita (2017)



(Retrieved from The World Bank, 2017)

Ultimately, if demand for healthcare services cannot be dampened, the affordability problem will most likely result into unviable financial burden for society. In this sense one of the most important tasks is to explore sources and originations of health variation and subsequently healthcare demand. By identifying these sources of health deprivation, potential measures and solutions can be put into place to mitigate the effect on health. This in terms should contribute to a reduction in excess healthcare demand and increase affordability.

Previous studies have identified three domains of determinants of health variation namely, behavioural characteristics such as unhealthy eating and no exercise. Next to that, socioeconomic status (including demographics) is found to be a determinant as well. The findings of Adams, Hurd, McFadden, Merrill and Ribeiro (2003) illustrate that socioeconomic status has shown to have a substantial impact on health through its four components: occupational status, education, civil status and income. Lastly, the environment is found to be a determinant for health variation as well. Schlenker and Walker (2016) argument that excess airplane idling increases the prevalence of respiratory –and heart related diseases. Furthermore, Currie, Davis, Greenstone and Walker (2015) investigated industrial plants and found that toxic air emissions are related to lower birth weights for babies being born within one mile from the plant. However, most economic literature on the health effect of the environment focused on the external environment and the effect climate change on health. One of the least studied topics concerns the effect of the indoor environmental conditions on public health. The indoor environment and housing conditions are considered to affect productivity, absenteeism, health

and comfort. According to Klepeis (2001) the majority of people's time in the United States is spent indoors, whether in residences, in schools, or in workplaces. Another study concerning seven regions of Europe found the same results and concluded that people spent 90 percent indoors (Schweizer et al. 2007). Therefore, most of the adverse exposures that people encounter take place indoors. Exposure is a function of pollutant levels and the time spent in contact with the pollutants. An early study conducted by Smith (1988) concluded that the human inhalation exposure to indoor air pollutants was 100 to 1000 times greater than to outside air pollutants. In addition, Bennet, Margni, McKone and Jolliet (2002) as well as Nazaroff (2008) argument that the effect of indoor pollution have a much larger effect on someone's health than outdoor pollution. Particularly young children, spend most of their time indoors. According to Cohen-Hubal et al. (2000) children under two years of age spend just under 94 percent of their time inside. In this light, children have been shown to be more vulnerable to the effects of exposure to a number of indoor chemicals. Although, this might also be driven by their metabolic rates, body size and immature immune responses (Faustman, Silbernagel, Fenske, Burbacher, & Ponce, 2000).

This study will be evaluating housing conditions as a proxy for indoor environment and is based on the findings of Aydin, Eichholtz, Kok and Palacios (2017), who indeed find a causal relationship between poor housing conditions and health issues for individuals living in rental dwellings. The paper is the first of its kind to prove a causal relationship using a large longitudinal dataset of German households. The study at hand aims to complement previous research and especially extent and validate the findings of Aydin et al. (2017). Next to that, Aydin et al. (2017) does not provide a direct link between poor housing conditions and specific health issues. The study at hand will specifically look into which health issues are driven by poor housing conditions. Last, this paper aims to increase robustness by controlling for self-selection bias. This means that the observed associations between health and housing in the paper of Aydin et al. (2017) are potentially inflated. It may induce bias that inhibits the establishment of causal relationships. This study seeks to contribute to the existing but limited research by analysing the potential causal relation between rental housing conditions and occupant health. Therefore, this study poses the following research question:

"What is the effect of poor housing conditions on health?"

The remainder of this paper is structured as follows. In section two the theoretical foundation regarding various determinants of health deprivation is outlined. This provides a solid basis for

this analysis of the effects of poor housing conditions on health. This section also elaborates on the Swiss rental housing market, which is characterized as largely rental in nature. In section three, the methodology of this study are provided including the main hypotheses, setting and sample and descriptive statistics. The fourth section outlines the empirical design and strategy. In section five, the results of the analysis are presented. Lastly, in section six the discussion is provided as well as the study's limitations and conclusion.

2. Theoretical framework

This study analyses the relationship between poor housing conditions and tenants' health. In order to conduct this research, a solid basis in terms of theoretical foundations should be posed as a rationale. This section covers the different underlying concepts in order to establish a causal relationship between poor housing conditions and health. Furthermore, it covers the economic impact and multiple drivers of health variation, the importance of tenancy status and an analysis of the Swiss housing market.

2.1 Economic impact of health variation

In the late 18th century Adam Smith was the first to define human resources as a type of fixed capital next to machines, land and property. He argued that the acquisition of skills and useful abilities should be viewed as a form of capital stock and as a produced means of production. The concept of human capital is only different from financial -and physical capital in the notion that it cannot be separated from its owner. Becker (1974) argues that acquiring knowledge and personal skills are a product of deliberate human investment. In this sense, human capital theory is aims to explain how education increases the productivity of workers and therefore increasing the level of cognitive stock of economic human capability (Schultz, 1971). The costs of investing in human capital can be found in the opportunity cost of the time lost for education and training purposes, in which a person could have been economically productive. The optimal quantity of human capital investment in acquiring skills and knowledge varies over the life cycle of an individual. According to Becker (1967) investments in human capital should fall with age as the return horizon decreases.

However, several early economic scholars (Mushkin, 1962; Becker, 1964) suggested that health can be viewed as a form of human capital as well. Grossman (1972) was the first to develop a model in which health is viewed as a form of human capital. Investing in health as human capital however differs from investing in education and training in the sense that it

produces different gains. In his model, he argues that acquiring knowledge and skills affects someone's market productivity, while investment in health affect the total amount of time someone can use his knowledge and skills producing capital gains. The amount of healthy days can be viewed as the return of investments in health. By combining inputs such as medical services and time for doctor visits, individuals invest in their health. The rationale behind investing in health is that the individual increases the length of time in which he or she can be productive. In human capital theory, investment in human capital should be the highest in the beginning of the lifecycle, with the amount of time devoted to education and training steadily decreasing as an individual gets older. In contrast, investing in health capital increases throughout the life cycle. People start to invest more in health as they get older (Blinder & Weiss, 1976). Even after retirement people invest in health, despite losing its importance in earning generation. This is a consequence of the fact that the rate of decay in health capital increases with age. Wagstaff (1986) suggests that as the time of death approaches throughout the lifecycle the fraction of time spent sick increases and therefore the medical service expenditures increase. The health capital investment model of Grossman (1972) has been applied to health-related subjects in order to determine the drivers of these investments, but also to explain variations in health and demand for medical care among individuals.

2.2 Drivers of health variation

Health variation can be viewed as differences in people's capability to function. According to the World Health Organization (2017) every individual on this planet should have the right to the highest attainable level of health. Despite this, there is still substantial variation among people. Many people in low-income countries do not enjoy the highest biologically possible health. In this context the variation in health is portrayed as a function of economic development or wealth. The variation in health among people was primarily related to differences in the amount of wealth. Due to various studies about income growth, it has become increasingly evident that not only differences in physical capital lead to variation in health. The identification of different factors affecting health variations between people have been the subject of multiple studies and analysis for decades. Literature on health economics documents relationships between certain factors and health in multiple domains, which take root into four main pillars: socioeconomic status (including demographics), individual behaviour, the external environment hazards and housing conditions and the indoor environment.

2.2.1 Socioeconomic status and demographics

Demographic factors such as age and gender are believed to causally affect healthcare utilization. Bertakis (2000) found that women had higher medical charges than men for multiple health services after controlling for self-rated health status, socioeconomic status and clinic assignment. Age also causally affects healthcare utilization. In the context of health capital investments, age increases the rate of decay in healthy days and therefore health capital investments increase throughout the life cycle.

Factors relating to socioeconomic status might influence someone's health as well. In his paper Antonovsky (1967) illustrated this effect as follows: *"The Titanic, rammed an iceberg on her maiden voyage in 1912. The official casualty lists showed that only 4 first class female passengers (3 voluntarily chose to stay on the ship) of a total of 143 were lost (3 percent). Among the second class passengers, 15 of 93 females drowned (16 percent) and among the third class, 81 of 179 female passengers went down with the ship (45 percent). Death is the final lot of all living beings, but the time at which one dies is related to one's class"* (p. 31).

Socioeconomic status has four main components that can affect health: (1) level of education, (2) civil status, (3) occupational status, and (4) economic status. Each of these explain distinctive aspects of an individual's social position. The effect of socioeconomic status on health has been studied on different number of populations, with the general finding that higher socioeconomic status is associated with better health and longer life (Antonovsky, 1967; Adams et al., 2003). This association is found in different genders and ages and occurs over different levels of socioeconomic status. The latter suggests that a marginal increase in socioeconomic status is associated with a marginal increase in health as well (Goldman, 2001). This relation holds for multiple health measures such as the number of days someone is affected by their health, self-rated health status, healthcare utilization, the number of doctor visits and mental well-being. Discussion about the causality of the association between health and socioeconomic status has been a subject of debate for years. This stems from the reasoning that poor health at the beginning of the life cycle reduces the ability to work and earn a decent living, which can be translated into lower socioeconomic status. Health incidents later on in the life cycle may also reduce the ability to work and increase medical care expenditures, leading to a decrease in socioeconomic status. However, the study conducted by (Adams et al., 2003) proves causality between socioeconomic status and health by using alternative measures as control checks including education level, income and occupational status. Mirowsky and Ross (1998) argue that the positive health effects of each component of socioeconomic status

goes beyond acting as a proxy for income and wealth. They find that, lack of money is likely to affect mental well-being as well as a result of stress associated with not having enough money to pay the bills or buy food.

A great deal of evidence suggests that a higher level of education leads to better health. Cutler and Lleras-Muney (2006) find a causal relationship between education (measured in years) and health. According to Mirowsky and Ross (2005), education's effect on health can be explained in twofold. First of all, education serves as a proxy for wealth, as education increases available economic resources to increase health. However, most of education's effect on health cannot be explained through this. Education gives people the resources to control and shape their own lives in a way that protects and increases health. High levels of personal control the number one reason that individuals engage in a healthy lifestyle. Education helps people avoid feelings of helplessness by providing skills and knowledge that reduce actual helplessness and increase effectiveness (Mirowsky & Ross, 2005). People who feel helpless do not see connections between their actions and important outcomes in their lives. However, different stages of education might explain variation in health to different extent. According to Akguc (2011) found that perceived personal control among individuals improves the most between secondary and tertiary education.

According to August and Sorkin (2010) marriage is positively associated with health status and mental well-being. Non-married individuals report higher mortality rates (50 percent higher among women and 250 percent higher among men). These ratios are particularly high for causes of death related to individual behaviour, including respiratory diseases and suicides. (Smith, Mercy, & Conn, 1988). According to (Ross, Mirowsky, & Goldsteen, 1990) marriage increases available economic resources and lowers economic hardship which leads to better health. However, most of the effect is channelled through emotional support, which decreases depression (Gerstel, Riessman, & Rosenfield, 1985). Support from one's husband or wife improves health several ways: by reducing risky behaviour and by early detection and treatment of health issues. Living with someone in a household without being married does not explain the patterns of marriage and well-being (Joensen et al., 2017). Even though the non-married have a larger number of supportive relationships, these typically do not provide as much emotional support.[1]

1. This study perceives marriage as a 'good' marriage without variation, as measuring the degree of 'goodness of marriage' and its impact on health are out of this study's scope. This study uses the variable 'Civil status', covering marriage, in order to explain the degree of variation in health

Bird and Fremont (1991), argue that with employment comes economic well-being, which results into improved economic resources to invest in health. In this line of reasoning, Conger and Elder (1994) find that employment increases household income and decreases economic hardship, both improving health status. In addition, the stress of trying to pay the bills for low-income households generates psychological distress. However, health variation as a result of unemployment reaches beyond acting as a proxy for income and wealth. Unemployment causes low sense of control which may lead to distress. According to Gallo, Bradley and Falba (2004), the role of stress in the development of heart-related diseases is well established. Literature has shown that involuntary job loss in the years preceding retirement can be a stressful event. Other studies show that unemployment may lead to bad habits, such as unhealthy eating (Darmon & Drewnowski, 2008), excessive alcohol consumption (Mossakowski, 2008), smoking on a regular basis (Fagan, Shavers, Lawrence, Gibson, & Ponder, 2007) and decreased physical activity (Grayson, 1993). Furthermore, a reduction in the level of income may discourage seeking medical attention to avoid treatment costs (Urbanos-Garrido & Valcarcel, 2015). Mirowsky and Ross (1995) find supporting evidence in favour of the argument that employment fosters health. They find that, over a one-year period, people with full-time jobs show no significant decline in health status, whereas unemployed men and women show significant average decreases in health status.

2.2.2 Individual behaviour

According to GBD 2015 Obesity collaborators (2017) 710 million people were reported to be obese in 2015, of which 107 million children. High body mass index ratios (BMI) accounted for 4.0 million deaths globally and the prevalence of obesity has increased over the years in most countries. More than two thirds of the reported deaths relating to obesity were due to heart-related diseases. Smoking habits can be identified as a behavioural driver of health variation as well. The study conducted by Fielding (1985) reported that among 565,000 annual deaths from heart-related diseases, 30 percent can be attributed to smoking. In each of the yearly reports of the U.S. Surgeon General, smoking has been identified as the number one source of preventable and premature deaths. In contrast to smoking, physical activity is considered as the most well-known determinant of health improvement. Lechner (2009) concluded that the involvement in regular physical activity has a positive effect on physical health and mental well-being.

2.2.3 External environment

Environmental economic literature has documented the adverse effects of environmental hazards on individual health. Many environmental economic scholars document the adverse health effects of air pollutants. In particular, Schlenker and Walker (2016) argue that excess airplane idling impacts the health of local residents. Especially, they find an increase in heart-related diseases. Currie et al. (2015) investigated industrial plants and found that air pollution is related to lower birth weights for baby's being born near the plant. Hanna and Olivia (2015) found that the closure of a large oil refinery in Mexico City led to a reduction of toxic emissions which resulted into less absenteeism and lead to an increase of 1.3 work hours per week.

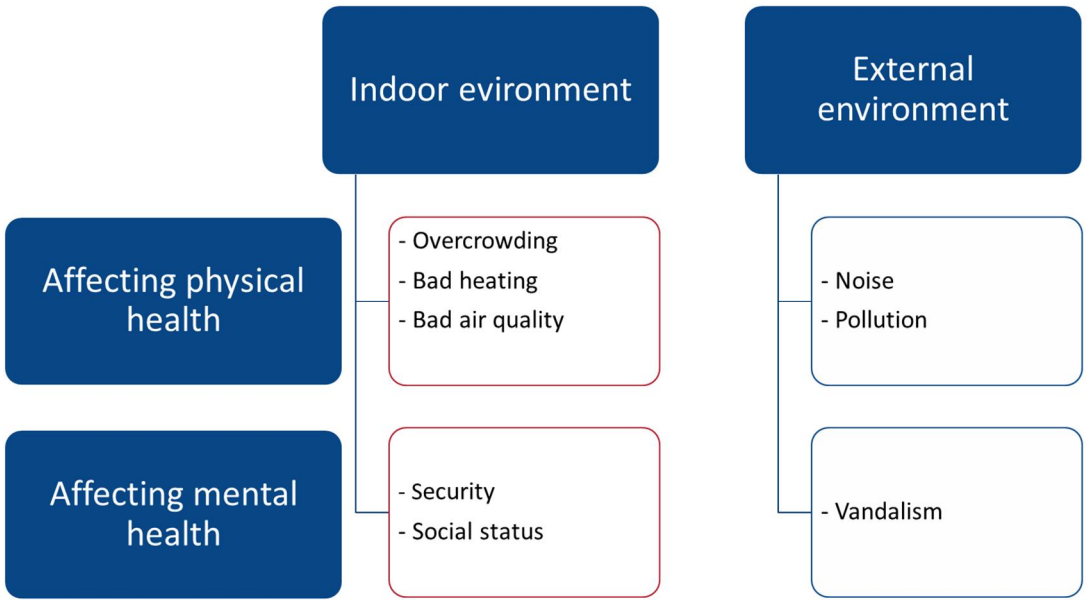
Environmental economic literature suggests that the location of one's home has an effect on health. The underlying assumption is that people living in bad neighbourhoods have a feeling of insecurity and anxiousness, which results into more stress and lower mental well-being. This argument is based on the 'Moving to opportunity' field experiment (Kling, Liebmann, & Katz, 2007). In this field experiment families living in low-income neighbourhoods were re-assigned to safer neighbourhoods that had lower poverty rates. They found that after the random re-assignment, these families reported improved mental well-being. Bilger (2013) reports that problematic neighbourhoods are strongly health damaging. He finds that the likelihood of having a chronic illness between good- and bad neighbourhoods is the same as between individuals who only had primary education and those who have more than secondary education.

Noise can be considered to be a topic of interest as well. It is assumed that exposure to traffic and airport noise have a negative effect on health. One could argue that traffic and airport noise is highly correlated with air quality. However, Basner and McGuire (2018) show that disproportionately high levels of traffic noise causally related with sleeping problems. Residential noise captures the noise that is produced within other residences related to the occupant's home. Residential noise is found to be unpredictable and often has a very high informational content (Niemann et al., 2006). Hammer, Swinburn and Neitzel (2013) estimate that neighbourhood noise puts millions of Americans at risk of heart disease and other health effects. Research however is limited because it difficult to measure. Lastly, Weinhold (2015) finds strong positive correlations between exposure to neighbourhood noise and a variety of health issues.

2.2.4 Indoor environment

The indoor environment in the sense of housing conditions is the scope of this study. However, it remains questionable which issues are directly related to the indoor environment. Figure 2 includes a table of factors which are related to indoor environment or external environment. In terms these factors are also divided into physical or material problems and mental or immaterial problems.

Figure 2. Overview of factors related to indoor and external environment



The upper-left quadrant outlines issues of the indoor environment level as determinants for physical health variation and includes bad heating, bad air quality and overcrowding, which refers to whether the size of the dwelling is perceived to be 'too small'. The lower-left quadrant refers to indoor environment related issues as determinants for mental health variation including the feeling of insecurity and low social status. External environmental hazards are identified as well in Figure 2. Noise, pollution and air quality are considered to affect physical health. Whereas, vandalism is believed to have an effect on mental health.

Economic literature concerning the effects of housing on health goes back almost two centuries. Chadwick (1843) documents the first association between housing and health. He argues that epidemics among the labouring classes are caused by atmospheric impurities produced by filth and damp and overcrowded dwellings. He also states that these epidemics can be prevented by better ventilation and proper cleansing. A century later Britten (1942) concluded that population living under adverse housing circumstances are subject to chronic

illness. McGregor (1963) found that poor dwelling quality leads to higher mortality rates, after studying slums in England and Wales. All in all, literature documents an adverse relationship between housing conditions and health. This relationship can be disentangled into multiple drivers. Indoor pollutants include emissions from building materials, processes that occur indoors (cooking and cleaning) and emissions as a result of individual behaviour of occupants. Next to that, outdoor pollutants can be transmitted indoors as well. According to the Institute of Medicine (2011) ventilation refers to the air-exchange mechanism of a building, which influences indoor air-pollutant concentrations. It is an important removal mechanism that limits accumulation of indoor pollutants. However, higher ventilation rates increase the accumulation of outdoor pollutants, indoors. Outdoor pollutants that enter a building interact with its components, thereby alter the indoor air quality in ways that can affect the health of occupants. Therefore, this study will use outdoor pollution as a proxy for indoor air quality.

Overcrowding occurs when the size of a dwelling does not meet the needs of the household. It's one of the most frequently employed indicators to measure indoor environmental quality. Britten et al. (1987) documents that overcrowding is negatively related to individual health status. In the early 20th century the effects of overcrowding have been studied as the effects of rapid industrialization and urbanization became problematic. Economic literature documents multiple resident-related issues such as Barker, Coggon, Osmond and Wickham (1990) who documented the association between domestic crowding and stomach cancer. Furthermore, short stature in adulthood has been found to be associated with overcrowding as well (Montgomery, Bartley, Cook, & Wadsworth, 1996). However, most notably health issues arise from closer contact between household members, this includes sleeping problems, lack of privacy and increased exposure to the spread of infections (Institute of Medicine, 2011). The main drivers behind overcrowding are rising housing costs and persistent shortage of affordable housing. This relation was first discussed in the 19th century by Chadwick (1843), but appears to remain relevant today as Easthope, Stone and Cheshire (2018) show.

Regarding inadequate heating, 'Sick Building Syndrome (SBS)' is vastly used as a term to define several nonspecific health symptoms, such as the irritation of eyes, fatigue, headaches, and decreased concentration capacity (Fiedler, 1998). According to Bonnefoy, Braubach, Davidson, and Robbel (2007) these health symptoms usually cannot be traced back to a specific cause, although it is known that ventilation and air-conditioning systems are closely related to the expression of SBS. Furthermore, Wilkinson, Landon, Armstrong, Stevenson and McKee, (2001) found that in the United Kingdom, the number of excess winter deaths are around

50,000 a year. This is partially caused by low indoor temperatures as a result of inadequate heating. In his study Wilkinson et al. (2001) found that 33 percent of all households reported cold temperature in winter, thereby showing a clear distinction among socioeconomic status.

Housing tenure captures whether a household owns or rents the dwelling. Previous scholars found housing tenure to be associated with mortality and health variation. Among those living in rental dwellings showed higher mortality rates (26 percent higher than those for owner occupiers among males, and 22 percent higher among females) (Macintyre et al., 2003; Macintyre, Ellaway, Der, Ford, & Hunt, 1998). Explanations for this association can be traced back to the 19th century in London. Poor housing and neighbourhood conditions were seen as key reasons for poor health among the poor. Economic literature viewed the relation between tenure and health is believed to simply be a marker of wealth and income through which health variation is explained. If this hypothesis were to be correct, then tenure would have little or no relationship with health once controlled for measures of wealth or income. Macintyre et al. (1998) tested the hypothesis and concluded that this was incomplete, suggesting that tenure was not simply acting as a proxy for income. The alternative hypothesis stated that tenancy status might on itself be directly health promoting or health damaging, independently of other measures of material well-being. Macintyre et al. (1998) found that the health-related issues were significantly associated with housing tenure even after controlling for age, sex and income.

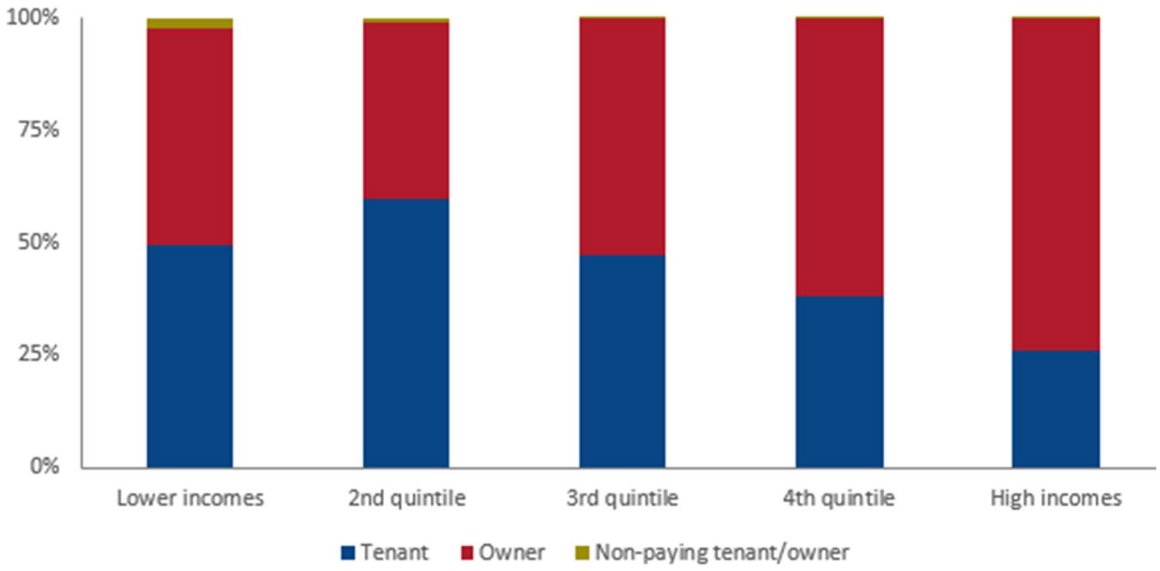
This is likely to stem from the notion that households who own and live in their dwelling are able to upgrade their personal health by investing in their homes. Tenants are more financially constrained and do not have the choice to upgrade their personal health by renovating their dwelling. Most likely they depend on the willingness of the landlord to improve indoor dwelling conditions. Unlike homeowners, tenants do not have a choice when it comes to improving dwelling quality. This is of interest for the study at hand in order to capture the relationship between health variation and housing conditions. By only focusing on tenants, this study might provoke discussion among regulators and lawmakers to tackle the problems tenants face.

2.3 The Swiss rental housing market

Thus far, previous literature captures the relationship between health and housing and its implications for healthcare demand. In order to provide a rationale for the relevant theory at hand, this section presents information on the Swiss rental housing market, which has the lowest rate of home ownership in the World, 38 percent, (OECD.Stat 2016). This section

includes specific characteristics of the rental market, such as an explanation for the low ownership-rate and present information on the cooperative housing sector.

Figure 3. Ownership rate per income quintile



Thalmann and Favarger (2002) found that in Switzerland 83 percent of respondents would prefer to be homeowners if there were no financial or other constraints. This suggests that the low ownership rate, as depicted in figure 3, in Switzerland is not a function of personal taste among its population. When comparing Switzerland to other countries one can observe that house prices/income ratio is relatively high. The reason for this can be attributed to constraints on availability of land for development. This is specific for Switzerland as its topography limits the amount of land, which can be developed for construction. Secondly, tight restrictions on the development of agricultural land also contribute to the high prices of dwellings. Next to that, owner-occupied homes are taxed heavily in Switzerland relative to other countries as they are subject to transfer, wealth, property, capital gains taxes. Lastly, down payment requirements are considered fairly rigorous for Swiss mortgage lenders with a minimum twenty percent deposit required in addition to closing costs. (Bourassa & Hoesli, 2010).

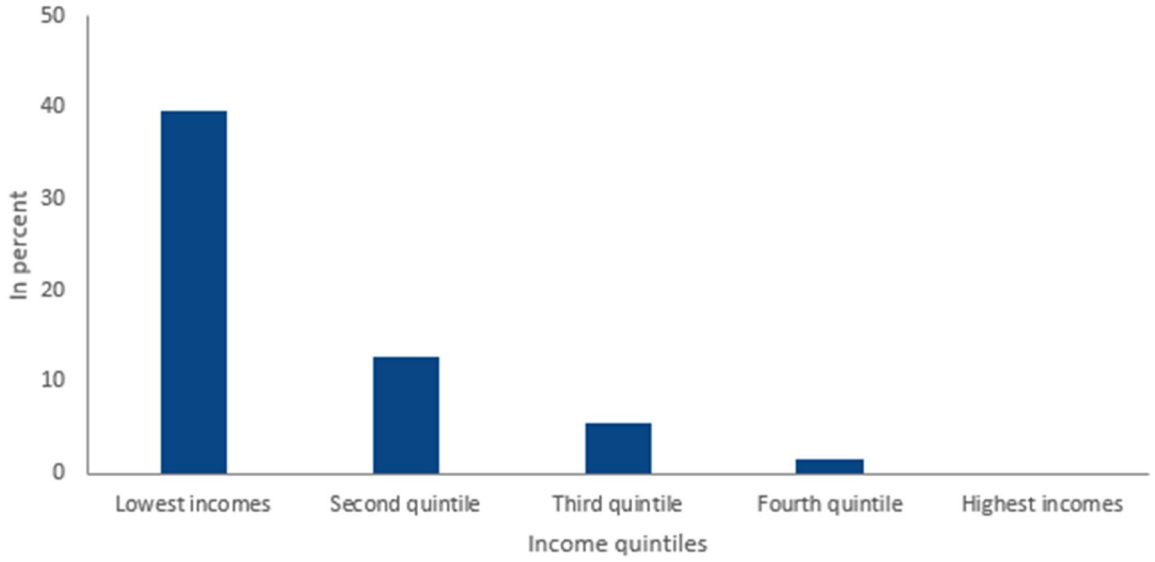
In contrast to owning, which is considered to be relatively expensive, renting seems to be relatively attractive. Switzerland has created landlord-tenants laws, which provide protection for tenants. These include restrictions on eviction and rent increases. Also, in some cantons rent is partially deductible from taxable income.

2.3.1 Social housing

The housing quality in Switzerland is of the highest in the world. However, Swiss housing policy faces quite a number of challenges, including high living costs, low levels of access to the housing market for specific groups of the population and a lack of social interaction (Glaser, 2017). The Swiss housing market is also characterized by a lack of social housing. In contrast to other European countries, social housing accounts only for a little fraction in the housing market. The country does not have a national policy for the provision of social housing, which is fully market based. This in terms means people are expected to find appropriate housing themselves according to the laws of demand and supply. Most rental housing is owned by private individuals or institutional investors. The share of non-profit housing cooperatives such as foundations and municipalities amount to only 5.1 percent in Switzerland in comparison to almost 30 percent in the Netherlands. There is a Swiss housing policy which provides a suitable regulatory framework to legislate against unfair rental practices, thereby protecting disadvantaged groups against unfair rental practices. In 2003 the federal housing act was adopted, which makes sure these tasks are implemented and places emphasis on cooperative housing (Swiss Federal Housing Office, 2016).

However, experience shows that average demand is what drives the market. By looking at the overburden rate in Switzerland, one can conclude that the cooperative housing sector is underdeveloped. Figure 4 illustrates the overburden-rate which outlines the percentage of households in a particular income quintile who pay more than 40 percent of their income on rental expenses. One can observe that 40 percent of the households belonging to the lowest income quintile pay more than 40 percent of their income on rental expenses. In comparison to other income quintiles this is excessive.

Figure 4. Overburden-rate per income quintile



During tight housing markets, low-income households are being priced out of the market. Consequently, affordable housing becomes scarce in urban areas. In conclusion, the Swiss housing market is able to provide high quality housing supply. However, the key challenge for the Swiss housing policy remains ensuring the access to proper housing for all groups of the population.

3. Methodology

This section includes the systematic and theoretical analysis of the methods applied. First of all, the study poses the main research hypothesis. After which, the setting and sample and underlying descriptive statistics are provided.

3.1. Hypotheses

The rationale for this study reflects the growing affordability problem regarding healthcare in high income countries. This study focuses on Switzerland in which the elderly population grows, demanding more healthcare and simultaneously the nonelderly population declines, putting a strain on the number of caregivers. In this light, multiple scholars have examined variation in health and studied factors relating to increased healthcare demand. So far, economic literature has focused on socioeconomic factors, environmental hazards and individual behaviours. However, housing conditions and indoor climate have received less attention. Only a handful of studies touched upon this topic. In high-income countries such as Switzerland, people spend most their time indoors. Therefore, housing conditions are likely to

have an effect on health. When studying the relationship between housing conditions and health, one needs to make a distinction between home-owners and tenants. The focus on this study lies on tenants as they are more constraint in upgrading their health by investing in their homes and are therefore more likely to be affected by poor housing conditions than home-owners. It is the responsibility of home-owners to resolve any issues regarding the indoor environment. In contrast, tenants depend on landlords to fix these issues. By separating home-owners from tenants, this study aims to determine a causal relationship between health and housing conditions. Next to that, tenants are found to be less wealthy and thus more often financially constrained. According to Macintyre et al. 2003, this results into increased exposure to hazardous built environment. This leads us to expect a negative relationship between poor housing conditions and tenants' health. Therefore, this study aims to answer following research question:

"Poor housing conditions negatively affect tenants' health"

In order to test the main research question, one should be clear the definition and measures used when referring to *'health'*, as the individual questionnaire used in this study refers to multiple health metrics. First, questions regarding self-assessed health and satisfaction with health status refer to subjective health measures. Whereas, the number of doctor visits and days affected refer to objective health measures. Therefore, the following hypotheses are posed as main hypotheses needed to answer our research question.

H1: Poor indoor environment negatively affects self-assessed health status
H2: Poor indoor environment positively affects the number of doctor visits

Previous literature regarding health capital have shown that an individual's health affects productivity. Grossman (1972) argued that the investments in human capital affect productivity, whereas investments in health affect the total amount of time an individual is able to put the investment in human capital to work. He viewed the amount of healthy and therefore productive days as return of health investments. This is of specific interest as the extent to which health status affects productivity loss can be economized. The questionnaire used in this study provides one indicator of productivity loss namely, the number days affected. Building on findings by previous scholars, this study expects that poor housing conditions negatively affect individual productivity. Therefore, the next hypothesis is posed as follows:

H3: Poor housing conditions positively affect the number of days affected

Next, this study will evaluate the effect of poor indoor environment on specific health issues such as: Back problems, weakness, sleeping problems and headaches. It is likely that poor indoor environment have different effects on these four specific health issues. However, it might be of interest to see which problems are a definite result of poor housing conditions and which are not. Therefore, the hypotheses are posed as follows:

H4a: Poor indoor environment positively affects health issues regarding back problems
H4b: Poor indoor environment positively affects health issues regarding weakness
H4c: Poor indoor environment positively affects health issues regarding sleeping problems
H4d: Poor indoor environment positively affects health issues regarding headaches

The study conducted Kling, Liebmann and Katz, (2007) regarding the "Moving to opportunity" field experiment aims to identify an increase in health status between pre-moving and post-moving years. In this field experiment families were relocated from high-poverty neighbourhoods to safer neighbourhoods. They found after the random re-assignment these families reported substantial improved mental health status. On the basis of this field experiment, this study expects that individuals who have moved during the length of the survey will have experienced significant health benefits. It is expected that individuals who are exposed less to poor housing conditions are less likely to suffer from the consequences regarding health. Although, it is expected that moving reduces the time to which an individual is exposed to poor housing conditions, it might also have the opposite effect if individuals move from a dwelling in good condition to a dwelling in poor condition. All in all, this study assumes that by excluding movers from the sample, it will increase the robustness. Therefore, the hypotheses stated above will be tested excluding individuals who moved during the survey as well.

3.2 Setting and sample

The Swiss Household Panel (SHP) used in this paper is retrieved from the FORS database. The aim of the SHP is to observe social change. In particular the dynamics of representations in the Swiss population and changing living conditions. The data is based on a random sample of households in Switzerland over time (18 years). Interviews of household members are mainly conducted by telephone. The SHP constitutes a unique longitudinal database for Switzerland

and covers a broad range of topics in the field of social sciences. It consists out of two distinct parts, namely a household questionnaire regarding various housing quality metrics and an individual questionnaire concerning multiple health measurements. Data collection started in 1999 with a sample of 5,074 households containing 12,931 household members. In 2004 a second sample of 2,538 households with a total of 6,569 household members was added and since 2013 the SHP contains a third sample of 4,093 households with 9,945 individuals. The data from the Swiss Household Panel is freely accessible to the scientific community.

The SHP dataset provided by FORS includes 226,000 unique observations. Thereof 96,733 are tenants. This study focuses on the relationship between housing conditions and health regarding tenants. The constructed dataset includes 60,211 viable observations spread over 18 years representing 12,490 unique individuals. The sample size varies every year, as the number of respondents change every year. The duration of individual participation ranges from 1 to 18 years and averages at around five years.

3.2.1 Housing measures

The study at hand aims to establish relationship between housing conditions and health. In the constructed dataset dwelling conditions are evaluated on several metrics based on the household module of the survey. The yearly repeated questionnaire contains questions regarding housing characteristics such as dwelling condition, dwelling satisfaction and several specific housing problems, including dwellings perceived to be too small, inadequate heating, poor indoor air quality. The type of dwelling is included as well. Respondents are asked to indicate in which type of dwelling they are currently living: ‘apartment’ ‘semi-detached’ or ‘other’. This might be of interest in order to see to which extent certain housing types are associated with dwelling problems and its relationship regarding specific health housing problems. The satisfaction of tenants regarding their dwelling is measured on a ten-point Likert scale with ‘0’ indicating dissatisfaction and ‘10’ indicating complete satisfaction. In order to determine whether households live in poor housing conditions, households were asked to indicate whether their dwelling is in poor condition or in good condition. In addition, the questionnaire incorporates a question relating to the size of the dwelling and whether it is perceived to be too small, which is used as a proxy for overcrowding. Respondents were also asked to indicate whether their dwelling could be heated adequately and whether they experienced poor indoor air quality. The answers to these questions are in the form of a binary response.

3.2.2 Health measures

Individual health can be measured in multiple ways. In order to capitalize on health and the relationship with housing conditions, this study aims to be as conclusive as possible. This study focuses on five different measures of health, which can be categorized in to two dimensions namely subjective and objective measures. Subjective measures consists out of self-assessed health status, health satisfaction and mental well-being. Whereas, objective measures are focused on healthcare utilization (the number of doctor visits) and productivity loss (number of days affected by health issues).

Individual health is analysed using multiple questions regarding health conditions such as self-assessed health status (e.g., *"How would you describe your health condition?"*). The self-assessed health status was rated on a five-point Likert scale ranging from 1= not well at all; to 5= very well. In order to use self-assessed health status in this study, the answers are codified as such that 'poor health status' is coded as '1' (consisting of the answers "not well at all, not well and so, so") and 'good health status' is coded as '0' (consisting of the answers "well and very well"). Health satisfaction is determined by the question, *"How satisfied are you with your health?"* This question was answered on a ten-point Likert scale ranging from '0' indicating "*not satisfied at all*" to '10' indicating "*completely satisfied*". Next to these general questions, the questionnaire also includes health questions regarding specific health issues such as back problems, weakness, sleeping problems, and headaches. The way in which these questions are posed is the similar to the question regarding 'poor health status'. The binary responses to these questions are used as variables in order to identify to which specific health issues, housing conditions are related.

In addition to health status, this study employs self-assessed measures regarding mental health as well. The following question regarding mental well-being is included in the questionnaire *"Do you ever feel depressed?"* The answers to this question range from '0' to '10' on a ten-point Likert scale.

Healthcare utilization refers to objective measures of health status. This is important when quantifying the effect of housing on individual health. The data used in this study provides two questions referring directly to healthcare utilization. Respondents are asked to report their healthcare demand by indicating *"the number of doctor visits in the last twelve months"*. Answers to this question range from "0" indicating never to 365 indicating every day. Next to that, the survey includes a question regarding the number of days affected as a result of health issues; *"Indicate the Number of days affected by health problems in the last twelve*

months". The answers regarding days affected by health problems, range from '0' (indicating never) to 365 days.

3.2.3 Control variables

Previous literature finds that socioeconomic factors have an effect on personal health. Therefore, it is crucial to take these factors into account when aiming to establish a direct relationship between the indoor environment and health status. As described, there are multiple personal specific indicators which affect someone's health or healthcare demand. Previous literature found that socioeconomic factors such as age, gender, income, civil status, occupation and education significantly influences health. The data at hand provides for these characteristics by incorporating relevant questions into the questionnaire. However, in order to use these variables, they needed to be constructed differently. For example, the variable *occupation status* is rephrased to *Full-time job* [2] in order to indicate whether someone is working full time. Next to that, the variable *educated* is constructed into whether the individual *attended tertiary education or not* and *civil status* is constructed into *married or not-married*. Responses to these constructed variables are all binary responses.

Multiple studies argue that health investments, increase the individual stock of someone's health capital. Therefore, behavioural indicators such as not practicing sports and unhealthy eating habits are also found to influence health status. The answers to questions regarding health investments are binary responses. However, factors determining whether someone is overweight needed to be constructed. This study uses the relevant personal data regarding individual height and weight, which are provided for 66 percent of the total observations. With this information one can construct a personal BMI score by dividing weight in kilograms by height in meters squared. This study employs this variable in order to control for unhealthy eating habits.

Previous literature finds that the external environment and neighbourhood characteristics have a significant impact on health as well. The questionnaire employed in this study covers multiple questions relating to the external environment. Respondent were asked about neighbourhood-related problems such as environmental noise and vandalism. They could indicate whether or not they experience a noisy external environment and vandalism problems in their neighbourhood.

[2] In this study keeping house, being in school or retired are seen as no full-time job as they all have one thing in common lack of pay.

3.2.4 Robustness check

In order to find a statistically significant relationship between poor housing conditions and health measures, this study makes use of a second dataset. This sub-dataset is retrieved from FORS and reflects a sub-study of the SHP about children aged below thirteen. The data is again based on a random sample of households in Switzerland over time (18 years). This sub-sample consists of information regarding children's health and is retrieved by interviewing parents mainly by telephone.

The subsample includes 15,870 unique observations spread over 18 years representing 3,600 unique individuals. The sample size varies every year, as the number of respondents varies every year. The duration of individual participation averages at around five years. The data consists of a household panel questionnaire regarding various measures of housing quality and a separate individual questionnaire regarding personal health.

3.3 Descriptive statistics

The SHP dataset consists of 226,000 observations regarding tenants and home-owners. However, this study aims to identify a significant relationship between housing conditions and health status regarding tenants. Stemming from the notion that tenants are more financially constrained and do not have the choice to upgrade their personal health by renovating their dwelling. However, it will be interesting to describe some descriptive statistics to strengthen previous claims regarding tenants and home-owners. Figure 5 indicates various health problems in relation to tenancy status. For every 'health-issues' category, the results are systematically worse for tenants than for homeowners. This relates to the literature, which states that people living in rental dwellings are more exposed to adverse housing conditions than homeowners. However, these health problems might not be attributed solely to tenancy status and might also affect socioeconomic status, external environment and behavioural characteristics.

Figure 5. Health problems in relation to tenancy status

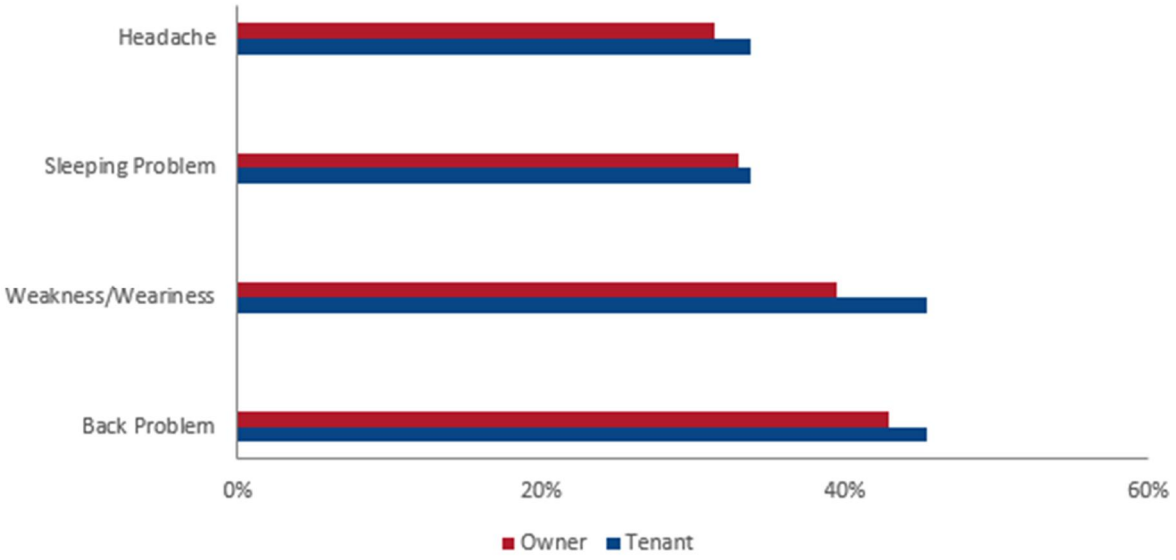
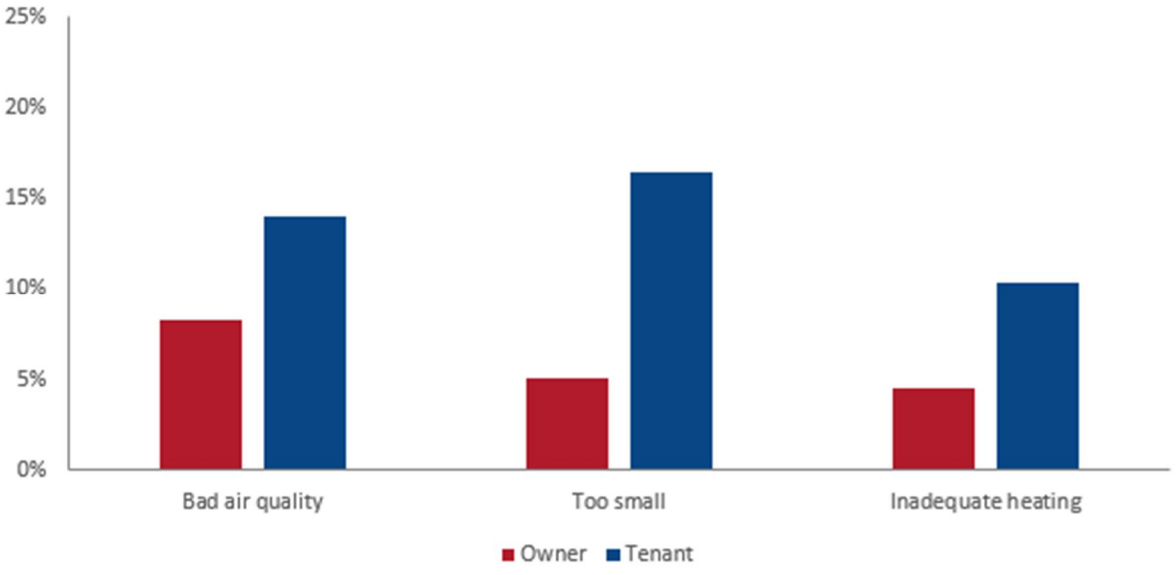


Figure 6 outlines the percentage of households experiencing specific dwelling-related problems. Strikingly, tenants report to observe systematically more dwelling-related issues than homeowners. A likely reason for this stems from the notion that homeowners are able to decide for themselves whether to resolve issues regarding dwelling-related problems. There is a difference in responsibility between occupants who rent and occupants who own. Taking inadequate heating as an example, tenants rely on their landlords to resolve this issue while home-owners have this responsibility themselves. Therefore, there is a dispersion regarding the incentive to resolve dwelling-related problems.

Figure 6. Percentage of households experiencing specific dwelling related problems



3.3.1 Health characteristics

As outlined in table 1, various health metrics are used to measure tenants' health. Furthermore, this study includes specific health issues such as back problems, weakness and weariness, headaches and sleeping problems. Looking at subjective self-assessed health status, one can observe that 16.8 percent of the sample report to suffer from poor health status. Nevertheless, satisfaction with health status is relatively high with a score of 7.8 on a ten-point scale. On average, respondents are affected by health problems roughly eleven days per year and make use of doctor visits 3.5 times a year. In addition, 77 percent of the respondents indicate that they visit a doctor at least once a year. Concerning specific health problems, we observe that on average that 45 percent of the respondents indicate that they experienced back problem in the last twelve months. Next to that, 33 percent reported headaches, 45 percent a feeling of weakness and 34 percent sleeping problems.

Table 1. Health characteristics of Swiss rental population

	Mean
Health characteristics	
General health status (1-5, 5=very well)	4.06
Poor health status (1=yes)	0.164
Health satisfaction (1-10, 1=very satisfied)	7.84
Number of days affected (yearly)	11.07
Number of doctor visits (yearly)	3.55
Feeling of depression (1-10, 10=depressed)	2.12
Specific health issues	
Back problems (1=yes)	0.438
Feeling of weakness (1=yes)	0.430
Sleeping problems (1=yes)	0.328
Headaches (1=yes)	0.319

3.3.2 Dwelling characteristics

The table below illustrates multiple dwelling characteristics of the survey used in this study. It outlines that on a ten-point scale the average housing satisfaction amounts to 7.9. Roughly ten percent are dissatisfied with their dwelling. Concerning housing conditions, the results show that 6.7 percent, amounting to 4,017 individual observations, indicate that the condition of their

current dwelling is below par. This can be attributed to specific issues such as 'too small', 'bad air quality' or 'badly heated'. Sixteen percent of the total observations indicate that respondents rate their dwelling as 'being too small', roughly ten percent report that their house is badly heated and fourteen percent report to experience bad air quality. 81 Percent of the respondents live in an apartment building, twelve percent in a detached or semi-detached home and seven percent in any other type of house/apartment.

Table 2. Housing characteristics of Swiss rental population

	Means
Housing characteristics	
Poor housing conditions (1=yes)	0.078
Housing satisfaction (1-10, 10=very satisfied)	7.85
Number of persons in household	2.5
Lives in apartment (1=yes0	0.81
Number of rooms	3.53
Log rent	7.24
Specific housing issues	
Too small (1=yes)	0.145
Inadequate heating (1=yes)	0.096
Poor air quality (1=yes)	0.142

In order to justify our study, figure 7 looks at the correlation between health measures and housing conditions regarding tenants in order to get an indication of the relationship between the two.

Figure 7. Average self-assessed health status in relation to dwelling condition

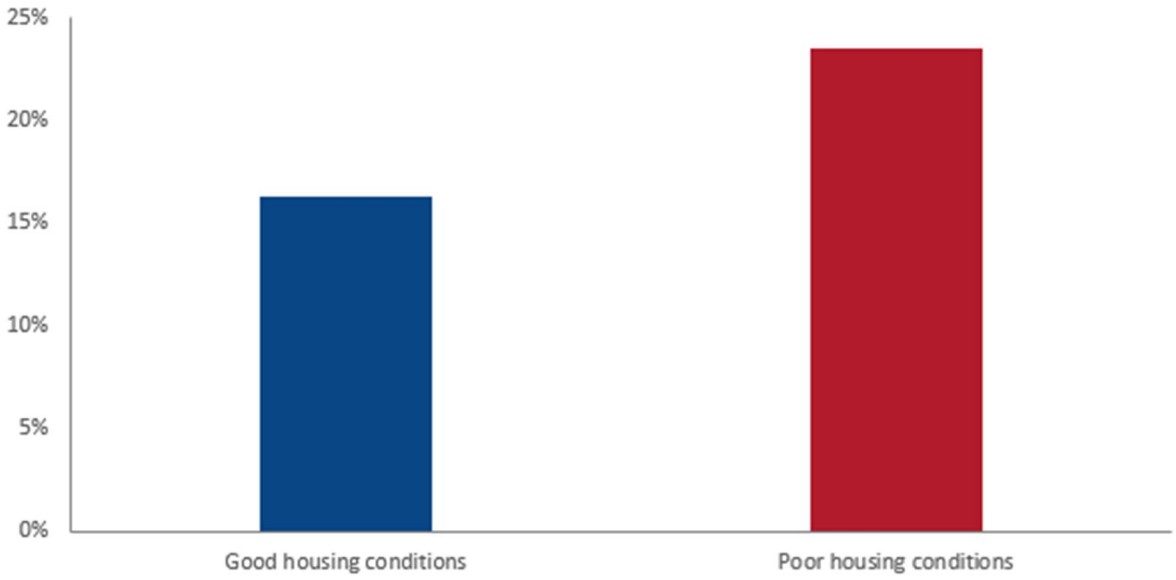


Figure 7 indicates that individuals living in poor housing conditions, report lower self-assessed health status on average. Specifically, 16.3 percent of the tenants living in good housing conditions report lower self-assessed health status. In contrast to 23.5 percent of the individuals living in poor housing conditions. Looking at objective health measures in Figure 8, one can observe a similar trend.

Figure 8. Objective health measures in relation to dwelling condition

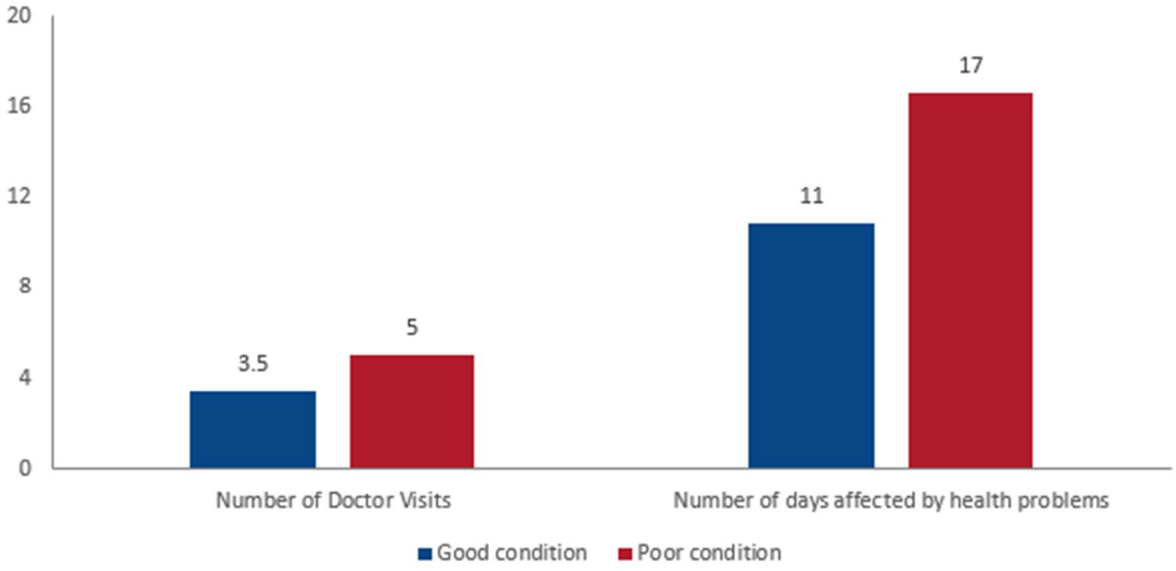


Figure 8 depicts 'Number of doctor visits' (indicator of healthcare utilization) and 'Number of days affected by health problems' with respect to housing conditions. Individuals living in good housing conditions score better on both health metrics. An individual living in poor housing conditions reports on average five doctor visits and is sixteen days affected by health problems on a yearly basis. Whereas, an individual living in good housing conditions reports on average 3.5 doctor visits and is roughly 11 days affected by health problems.

These descriptive statistics outline that there is a possibility of a significant causal relationship between housing conditions and health. However, there are multiple other factors which need to be taken into account before such a relationship can be established. It may be that this relationship is merely driven by other indicators such as socioeconomic characteristics, individual behaviours and the external environment.

3.3.3 Individual characteristics, behaviours and the external environment

The relationship between housing conditions and health could be driven by other factors such as socioeconomic -and behavioural characteristics or environmental hazards. As outlined before, earlier studies have studied the links between socioeconomic status and health, which reflects distinctive aspects of an individual's social position. Next to that, age and gender need to be taken into account as this might be of interest to capture the exclusive relationship between housing conditions and health. Lastly, behavioural factors such as unhealthy eating habits (captured by the 'BMI' variable in this study) and practicing sports have proven to affect demand for healthcare. As to get an indication of the relationship between these factors and health, table 3 outlines multiple factors and its relationship with different health measures. For example, 20.6 percent of the individuals who indicate to have no full-time job indicate report to suffer from poor health status.

Table 3. Overview of socioeconomic, behavioral and external characteristics in relation to health status and number of doctor visits

	Mean	
	Poor health status (1=yes)	**Number of doctor visits**
Socioeconomic characteristics		
Married (not-married)	0.171 (0.165)	3.6 (3.5)
Full-time job (no full-time job)	0.109 (0.206)	2.2 (4.4)
Attended tertiary education (did not)	0.11 (0.18)	2.9 (3.7)
Male (female)	0.131 (0.196)	2.6 (4.3)
Behavioural characteristics		
Practices sports (does not)	0.131 (0.233)	3.0 (4.5)
Healthy eating habits (unhealthy eating habits)	0.144 (0.216)	3.1 (4.5)
External characteristics		
Noisy neighbourhood (quiet neighbourhood)	0.197 (0.156)	4.0 (3.4)
Vandalism problems (no vandalism problems)	0.236 (0.157)	5.0 (3.3)

Table 3 indicates that individuals with lower socioeconomic status and bad behavioural characteristics systematically report poorer health. This is in line with previous studies which established a relationship between socioeconomic characteristics and individual health. However, multiple confounding factors might explain the results obtained in table 3. For example, the fact that 'not working full-time' is detrimental for health status does not take into account the age of the individual. Retired people are included in the 'no full-time job' category, which inflates the relationship with health status and number of doctor visits. Therefore, table 3 should be used as rough picture of the relationship between the control measures used in this study and health.

Figure 9 shows the distribution of household income and age across five quintiles. The health status of respondents within each quintile is measured and projected in the table. Self-assessed health status is known to be related with the human lifecycle. Next to that, the percentage of individuals describing their health status as 'poor', range from 25.7 percent in the lowest income quintile to 10.5 percent in the highest income quintile. This is in line with previous studies who found a relationship between age and health status and income and health status.

Figure 9. Relationship between age and health status & household income and health status

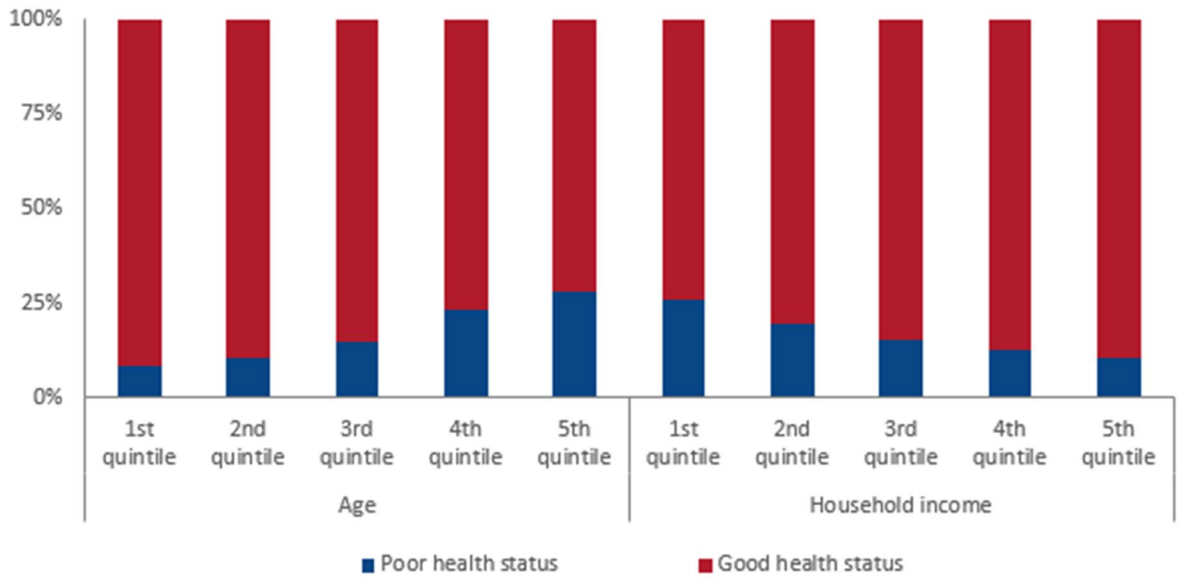
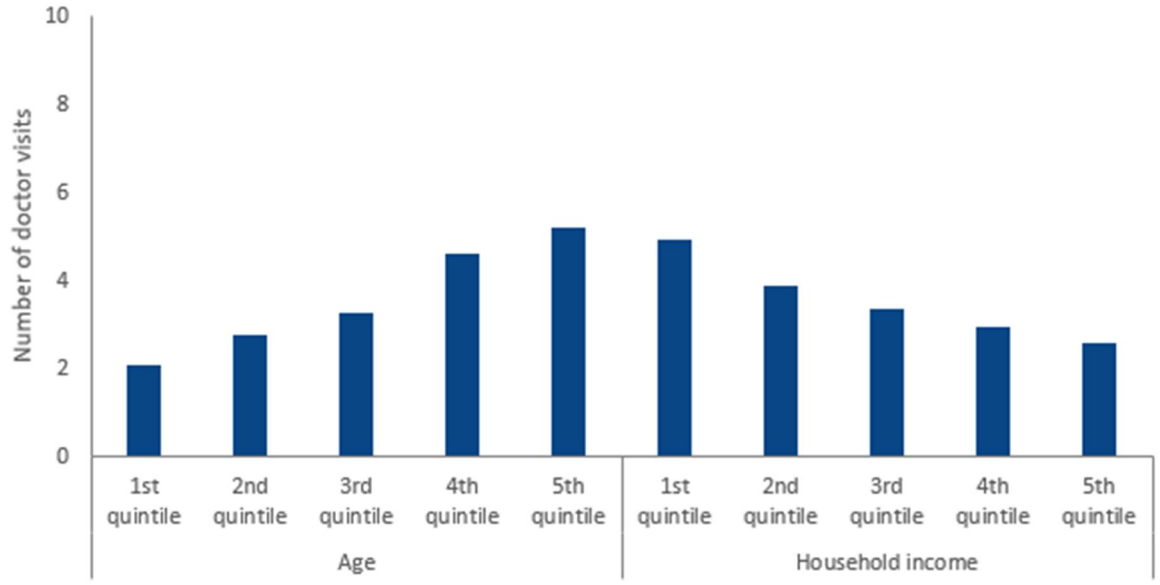


Figure 10 outlines the relationship between age as well as income with the number of doctor visits. One can observe that the demand for healthcare, translated in "number of doctor visits" is systematically higher for individuals of older age and individuals in the lowest income quintile. On average, the number of doctor visits related to age range from two for individuals in the youngest quintile to five for individuals in the oldest quintile. For household income, the

answers range from five doctor visits for the lowest income quintile to 2.6 doctor visits for individuals in the highest quintile.

Figure 10. Relationship between age and number of doctor visits & household income and doctor visits



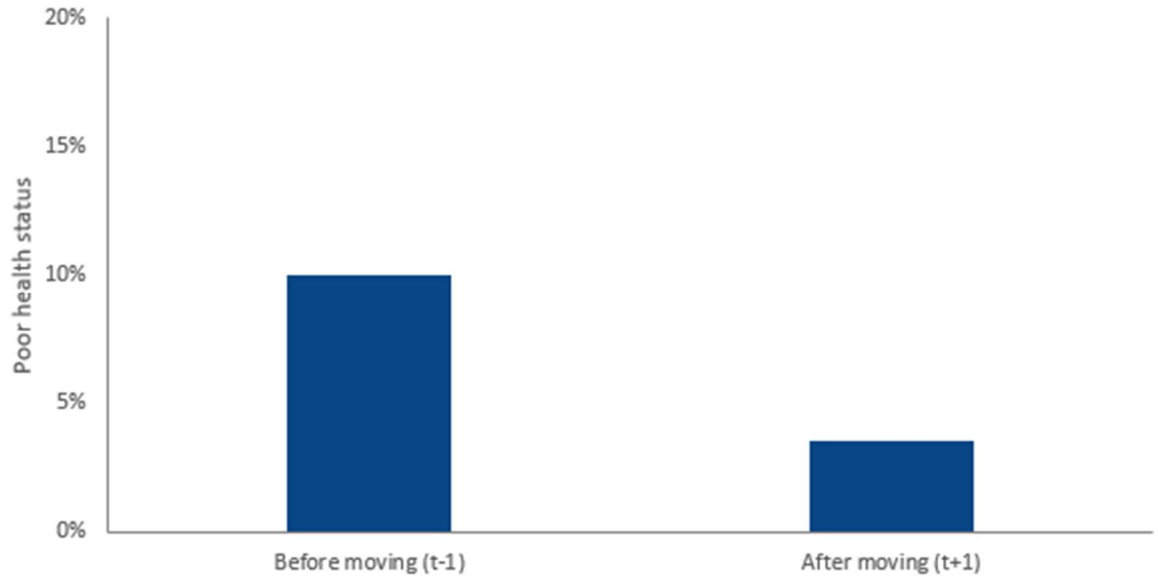
An overview of the means of all health variables with respect to housing conditions is provided in table 13 in the appendix.

3.3.4 The effect of moving on health

It may be of specific interest to see whether a person who moved during the survey, benefits from better health. This study employs the general believe that the housing quality of individuals who move, significantly increases as people are less exposed to poor housing conditions. Although, it might also be possible that individuals move from a dwelling which is in good condition to a dwelling which is in poor condition. Figure 11 illustrates the percentage of individuals living in poor housing conditions. From table 12 (appendix) we can conclude that 7.8 percent of the individual observations in the survey indicate that they live in poor housing conditions. The second column in figure 11 shows individuals who indicated that they moved since the survey. It shows that ten percent indicate living in poor housing conditions one year before moving. Strikingly, only 3.5 percent indicate that they live in poor housing conditions one year after moving. The change in housing conditions due to moving to a better dwelling might also affect demand for healthcare and self-assessed health status. Next to that,

this paper finds that individuals who did not move in the survey report 3.7 doctor visits on average, while individuals who did move report only 3.3 doctor visits on average.

Figure 11. Percentage of poor health status in relation to year of moving



4. Empirical analysis

As the descriptive statistics illustrate, there is a rationale for evaluating the relationship between housing quality and effects regarding health. In order to establish such a relationship, a longitudinal study is employed to determine the causality and strength of this relationship. The advantage of using panel data in this paper is that it enables to measure and analyse changes in socioeconomic status, individual health and housing situations over a time period of eighteen years in this case. Household panels enable researchers to study household change and the changing dynamics of the individuals within the household. By evaluating the evidence over time, one is able to determine the true extent of the causal relationship between two variables. The independent variable takes the form of general housing condition or specific issues relating to the quality of the dwelling. Whereas, various health measures are used to outline tenants' health. To isolate the causal relationship between the two variables, this study employs various control variables. We employ time and individual fixed effects in order to control for unobserved variations overtime and in our most robust analysis this study excludes '*movers*' from the sample.

4.1 Empirical strategy

Health measures can be split into subjective and objective health measures. Subjective health measures include self-assessed health status, health satisfaction, and the extent to which someone is depressed whereas objective health measures include number of doctor visits and number of days affected by health issues. This study employs both subjective and objective measures in order to establish a causal relationship with housing conditions. Housing conditions is measured according to self-assessed dwelling condition, however specific indicators of housing quality are used as well such as poor air quality, inadequate heating and dwellings perceived as "being too small". Demand for healthcare might be of specific interest to governmental bodies in order to economize the effect of poor housing conditions. Therefore, the objective health measures such as number of doctor visits and number of days affected are of specific importance. Next to general subjective and objective measures of health status, specific health problems are outlined as well. This study also aims to find a causal relationship between housing quality and specific health issues such as back problems, sleeping problems, weakness and headaches. Several control variables will be used in this study to isolate the effect of housing quality on the different health metrics. These control variables can be categorized in three distinct classes, namely behavioural characteristics, socioeconomic/demographic characteristics and environmental hazards. More specifically behavioural characteristics unhealthy eating habits as captured by the BMI variable and whether an individual practices sports. Socioeconomic characteristics include household income, level of education, civil status and occupation status, next to these demographic variables such as age and sex will be taken into account as well. Third, environmental hazards include neighbourhood vandalism and noise. Lastly, other household and dwelling related factors will be used as control variables such as number of rooms, number of household member and monthly rent.

4.2 Model specification

The model used in this study in order to establish a causal relationship between housing conditions and health is a pooled multiple linear fixed effects regression model. The model fits regression models to panel data used in this study, which allows to control for unobserved variables through fixed effects. The study at hand employs fixed effects, as to control for the impact of variables that may change over time. Each participant in the survey has its own individual characteristics that can influence the relation between housing conditions and health. Therefore, our model looks as follows:

$$Health'_{i,d,t} = a_i + \beta Housing\ conditions'_{i,d,t} + \delta X'_{i,d,t} + \theta Y'_{i,d,t} + \mu Z'_{i,dt,} + t_{i,d,t} + \varepsilon_{i,d,t}$$

Health' represents the vector of the dependent variable of individual *i*, living in dwelling *d*, in year *t*. The dependent variable captures various health measures such as 'self-assessed health status', 'health satisfaction', 'depression', 'number of doctor visits' and 'number of days affected'. The independent variable of interest is *Housing conditions'*, representing the effect of housing conditions on the dependent variable capturing various health measures. *Housing conditions'* includes specific housing problems as well such as 'too small', 'inadequate heating' and 'poor indoor air quality'. These *housing conditions*' variables measure the condition of the dwelling and indoor environment of dwelling *d* at time *t*. In order to control for other factors related to the dependent variable, this study includes three sets of control variables. The vector $\theta Y'_{i,d,t}$ includes the behavioural characteristics of individual *i*, living in dwelling *d*, in year *t*. Next to that, $\theta Y'_{i,d,t}$ captures issues regarding the external environment such as neighbourhood noise and prevalence of vandalism. Specifically, it captures external environmental problems of person *i*, living in dwelling d, in year t. Lastly, the vector$\mu Z'_{i,dt,}$ controls for all housing characteristics such as rent and whether someone live in an apartment.

Furthermore, this study also controls for unobserved components which influence the causal relationship between housing conditions and health. In the model time-invariant idiosyncratic and time-variant effects are included in this paper as fixed effects and denoted by $(t_{i,d,t})$ .This vector is used to control for unobserved characteristics, which may or may not interfere with the causal relationship between housing conditions and health.

5. Results

This section presents the empirical results of the estimated model, which is summarized in tables 4 through 11. The objective of these models is to estimate the causal relationship between housing conditions and health. The full tables including all control variables are presented in the appendix.

5.1 The effect of housing conditions on self-assessed health status

Table 4 outlines the effects of poor housing conditions on subjective health measures including self-assessed poor health, health satisfaction and the extent to which the respondent feels depressed. In order to ensure that the variation between poor housing conditions and subjective health measures is not distorted this model includes time fixed effects and individual fixed effects. Next to that, multiple control variables as mentioned previously are included in the

model. The study includes 39,769 observations over a period of eighteen years. In the analysis outdoor air quality is used as a proxy for indoor air quality. According the Institute of Medicine 2011 ventilation refers to the air-exchange mechanism of a dwelling, which influences indoor air-pollutant concentrations and higher ventilation rates increase the accumulation of outdoor pollutants, indoors. The year fixed effects results are reported in column (1), (3), (5), (7), and (11). Column (1) outlines that respondents who indicate that they live in poor housing conditions are 4.6 percent more likely to report poor health status. Next to that, they report 0.21 lower health satisfaction (1-10 scale) and report a 0.21 higher depression score (1-10 scale). Columns (3), (7), and (11) of table 4 also outline the effect of specific housing problems on subjective health measures. The model finds that individuals experiencing problems regarding inadequate heating, are 2.7 percent more likely to endure poor health, report 0.05 lower health satisfaction and a 0.12 higher depression score. Furthermore, individuals experiencing poor indoor air quality, are 3.6 percent more likely to report poor health, report 0.12 lower health satisfaction scores and 0.14 higher depression scores. By including individual fixed effects this study aims to be increase robustness by controlling for unobserved individual variation. The individual fixed effect results are reported in columns (2), (4), (6), (8), (10), (12) and obtain weaker or no significant relationships in contrast to the time-fixed effect model. Individuals living in poor housing conditions report on average 0.12 lower health satisfaction and 0.13 higher depression scores. Furthermore, we find that respondents who indicate to experience poor indoor air quality are two percent more likely to suffer from poor health status.

Table 4. The effect of housing conditions on subjective health measures for tenants

	(1) Poor health (1=Yes)	(2)	(3)	(4)	(5) Health satisfaction (1-10)	(6)	(7)	(8)	(9) Depression (1-10)	(10)	(11)	(12)
Poor housing conditions (1=yes)	0.046***	0.014			-0.212***	-0.117***			0.210***	0.125***		
	(5.67)	(1.49)			(-5.88)	(-2.97)			(5.02)	(2.76)		
Too small			0.012**	0.007			-0.050**	0.002			0.066**	0.032
			(2.17)	(1.04)			(-1.96)	(0.05)			(2.20)	(0.98)
Inadequate heating			0.027***	0.008			-0.055**	0.011			0.120***	0.069**
			(4.50)	(1.20)			(-2.09)	(0.38)			(3.99)	(2.14)
Poor air quality			0.036***	0.020***			-0.122***	-0.057*			0.142***	0.070**
			(5.97)	(2.88)			(-4.52)	(-1.92)			(4.55)	(2.05)
Sports	-0.051***	-0.029***	-0.051***	-0.029***	0.239***	0.174***	0.239***	0.174***	-0.146***	-0.080***	-0.146***	-0.081***
	(-12.94)	(-6.45)	(-12.89)	(-6.46)	(13.50)	(9.09)	(13.50)	(9.12)	(-7.14)	(-3.65)	(-7.13)	(-3.67)
BMI	0.006***	0.001	0.006***	0.000	-0.053***	-0.033***	-0.054***	-0.033***	0.000	-0.032***	0.001	-0.032***
	(10.07)	(0.12)	(10.23)	(0.14)	(-16.34)	(-5.98)	(-16.44)	(-5.95)	(0.03)	(-5.00)	(0.12)	(-5.00)
Noisy environment	0.019***	0.008*	0.012***	0.006	-0.064***	-0.005	-0.048**	-0.001	0.113***	0.043*	0.091***	0.034
	(4.37)	(1.65)	(2.82)	(1.13)	(-3.33)	(-0.23)	(-2.43)	(-0.02)	(5.09)	(1.76)	(4.03)	(1.38)
Vandalism environment	0.025***	0.004	0.022***	0.003	-0.050**	0.020	-0.042*	0.021	0.078***	0.006	0.067**	0.0015
	(4.45)	(0.69)	(3.86)	(0.49)	(-1.98)	(0.73)	(-1.67)	(0.78)	(2.68)	(0.18)	(2.30)	(0.05)
_cons	0.280***	-0.040	0.267***	-0.051	8.832***	10.85***	8.841***	10.81***	4.796***	3.443***	4.734***	3.387***
	(4.94)	(-0.40)	(4.70)	(-0.57)	(31.52)	(28.94)	(31.46)	(28.69)	(14.61)	(7.99)	(14.37)	(7.82)
Observations	39769	39769	39769	39769	39769	39769	39769	39769	39769	39769	39769	39769
R-squared	0.003	0.004	0.003	0.005	0.024	0.027	0.026	0.026	0.004	0.006	0.004	0.006
Socio-economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed-effects	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.2 The effect of housing conditions on healthcare demand

This study aims to examine the effects of poor housing conditions on healthcare demand. We assume that people living in poor housing conditions demand more healthcare than individuals living in good housing conditions. If these individuals demand more healthcare, the collective bill of healthcare expenditures will rise, making healthcare less affordable. In order to evaluate this, this paper uses the number of doctor visits as a proxy for healthcare demand. Column (1) of table 5 indicates that respondents living in poor housing conditions report to visit the doctor one time (1.02) more often than respondents living in good housing conditions annually. Next to that, the number of days affected because of health issues are reported as well. This in terms refers to productivity loss between individuals living in poor housing conditions versus individuals living in good housing conditions. Column (5) indicates that individuals living in poor housing conditions are also 2.1 days per year more affected by health issues. Individuals experiencing specific housing problems are also more likely to visit the doctor more often. Column (3) outlines that respondents who indicate their dwelling to be "too small" report 0.55 more doctor visits yearly and respondents enduring inadequate heating report 0.46 more doctor visits. Interestingly, specific housing problems do not affect the number of days affected by health issues (column 7). The individual fixed effects results are reported in columns (2), (4), (6) and (8) in table 5. From this we document that individuals living in poor housing conditions report 0.5 more doctor visits yearly than individuals living in good housing conditions (column 2). Column (4) shows individuals living in housing conditions perceived to be "too small" and with inadequate heating visit the doctor more often, namely 0.41 and 0.34 respectively.

Table 5. The effect of housing conditions on objective health measures for tenants

	(1) Number of doctor visits	(2)	(3)	(4)	(5) Number of days affected	(6)	(7)	(8)
Poor housing conditions (1=yes)	1.016***	0.514**			2.101**	-0.900		
	(4.75)	(2.09)			(2.07)	(-0.77)		
Too small			0.549***	0.414**			0.447	-0.533
			(3.63)	(2.33)			(0.62)	(-0.63)
Inadequate heating			0.463***	0.340*			0.990	-0.0572
			(2.98)	(1.95)			(1.34)	(-0.07)
Poor air quality			0.0802	-0.125			1.628*	0.942
			(0.50)	(-0.67)			(2.16)	(1.07)
Practices sports	-0.723***	0.491***	0.722***	0.490***	-6.054***	4.863***	6.046***	4.864***
	(-6.86)	(-4.11)	(-6.85)	(-4.11)	(-12.13)	(-8.60)	(-12.11)	(-8.60)
BMI	0.123***	0.025	0.124***	0.026	0.531***	0.007	0.535***	0.009
	(7.38)	(0.74)	(7.46)	(0.74)	(6.63)	(0.04)	(6.67)	(0.05)
Noisy environment	0.143	0.0054	0.126	0.010	1.572***	1.124	1.312**	1.012
	(1.28)	(0.04)	(1.09)	(0.07)	(2.95)	(1.80)	(2.40)	(1.59)
Vandalism environment	0.513***	0.170	0.506***	0.168	2.731***	1.768*	2.598***	1.717*
	(3.44)	(1.00)	(3.37)	(0.98)	(3.86)	(2.19)	(3.66)	(2.12)
_cons	4.286***	4.107	3.962***	3.640	23.70***	12.03	23.32***	11.99
	(2.80)	(1.75)	(2.58)	(1.55)	(3.24)	(1.08)	(3.18)	(1.08)
Observations	39769	39769	39769	39769	39769	39769	39769	39769
R-squared	0.003	0.004	0.003	0.005	0.006	0.008	0.006	0.007
Controls included	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed-effects	No	Yes	No	Yes	No	Yes	No	Yes

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

5.3 The effect of housing conditions on specific health measures

In the next section, this study will evaluate the effect of poor housing conditions on specific health issues such as: back problems, feeling of weakness, sleeping problems and headaches. In order to be more conclusive, this study aims to identify through which specific housing issues the relationship between poor housing conditions and health is channelled.

Table 6. The relationship between housing conditions and specific health issues for tenants

	(1) Back problems (1=yes)	(2)	(3)	(4)	(5) Weakness (1=yes)	(6)	(7)	(8)	(9) Sleep problems (1=yes)	(10)	(11)	(12)	(13) Headache (1=yes)	(14)	(15)	(16)
Poor housing conditions	0.003	-0.011			0.028**	0.010			0.037***	0.018			0.030***	0.013		
	(0.23)	(-0.81)			(2.35)	(0.72)			(3.28)	(1.44)			(2.73)	(1.08)		
Too small			0.018**	0.015*			0.024***	0.006			0.021***	0.012			-0.003	-0.004
			(2.34)	(1.75)			(3.06)	(0.62)			(2.82)	(1.40)			(-0.40)	(-0.50)
Inadequate heating			0.004	-0.002			0.012	-0.006			0.014*	0.003			0.011	0.001
			(0.49)	(-0.25)			(1.55)	(-0.70)			(1.89)	(0.40)			(1.47)	(0.07)
Poor air quality			0.017**	0.012			0.021***	0.005			0.033***	0.021**			0.010	0.009
			(2.17)	(1.30)			(2.64)	(0.52)			(4.33)	(2.44)			(1.36)	(1.07)
Practices sports	-0.013**	0.001	-0.012**	0.002	-0.037***	-0.013	-0.034***	-0.008	-0.022***	-0.014*	-0.019***	-0.009	-0.001	0.007	-0.001	0.006
	(-2.20)	(0.17)	(-2.33)	(0.26)	(-6.40)	(-1.94)	(-6.42)	(-1.30)	(-4.00)	(-2.27)	(-3.80)	(-1.51)	(-0.14)	(1.12)	(-0.19)	(1.03)
BMI	0.007***	0.008***	0.007***	0.008***	0.001	0.000	0.001	0.000	0.000	0.001	0.000	0.001	0.005***	0.003	0.005***	0.003*
	(7.10)	(4.07)	(8.45)	(4.88)	(0.77)	(-0.38)	(1.53)	(-0.10)	(-0.01)	(0.64)	(0.09)	(0.41)	(5.32)	(1.47)	(5.81)	(1.88)
Noisy environment	0.035***	0.021***	0.025***	0.014**	0.014**	-0.010	0.011*	-0.009	0.040***	0.019***	0.036***	0.018***	0.020***	0.012*	0.016***	0.011*
	(5.70)	(3.00)	(4.24)	(2.15)	(2.23)	(-1.41)	(1.89)	(-1.34)	(6.67)	(2.77)	(6.48)	(2.83)	(3.38)	(1.78)	(2.98)	(1.70)
Vandalism environment	0.024***	0.006	0.018**	0.000	0.035***	0.013	0.031***	0.014	0.026***	0.007	0.023***	0.010	0.007	-0.001	0.008	-0.001
	(2.88)	(0.60)	(2.37)	(0.03)	(4.24)	(1.42)	(4.03)	(1.56)	(3.34)	(0.78)	(3.21)	(1.13)	(0.97)	(-0.08)	(1.18)	(-0.14)
_cons	0.634***	0.215*	0.543***	0.180	0.789***	-0.039	0.723***	-0.011	0.411***	0.024	0.452***	0.116	0.538***	0.518***	0.521***	0.456***
	(7.18)	(1.64)	(6.88)	(1.56)	(9.00)	(-0.29)	(9.23)	(-0.10)	(4.85)	(0.19)	(5.98)	(1.05)	(6.52)	(4.24)	(7.04)	(4.21)
Observations	33366	33366	39769	39769	33366	33366	39769	39769	33366	33366	39769	39769	33366	33366	39769	39769
R-squared	0.003	0.005	0.004	0.005	0.003	0.006	0.003	0.005	0.003	0.005	0.004	0.00459	0.001	0.002	0.001	0.002
Socio-economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed-effects	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

In table 6 the relationship between poor housing conditions and specific health issues for all tenants in the constructed dataset is analysed. Again, year fixed effects and time fixed effects are included in order to ensure that variations are not influenced by a specific time period or unobserved individual variables. Considering only time fixed effects, one can identify that poor housing conditions significantly affect specific health problems including feeling of weakness, sleeping problems and headaches. There seems to be no significant relationship between poor housing conditions and back problems. This intuitively makes sense as the literature suggests that back problems are mostly caused by individual specific characteristics such as being overweight, lack of exercise and also posture. Individuals who report to live in poor housing conditions are 2.8 percent more likely to experience a feeling of weakness, 3.7 percent more likely to endure sleeping problems and three percent more likely to be affected by headaches. These relationships are estimated to be significant on the five percent level at least.

In order to be more conclusive this study aims to identify which specific housing issues are causing which specific health problems. Columns (3), (7), and (10) in table 6 provide a more detailed approach towards identifying the relationship between poor housing conditions and specific health issues. One can observe that all three specific indicators of poor housing conditions are significantly related to different specific health issues. There is variation in the strength of the relationship among the various indicators. Interestingly, different specific health issues are caused by different specific housing conditions. Respondents indicating they experience poor air quality are 1.7 percent more likely to experience back problems, 3.3 percent more likely to experience sleeping problems and are 2.1 percent more likely to endure a feeling of weakness. Next to that, individuals who report that their housing conditions are perceived as ‘too small’ are believed to be more likely to endure back problems (1.8 percent), sleeping problems (2.1 percent) and feeling of weakness (2.4 percent). Lastly, inadequate heating is only significantly related to sleeping problems, meaning that individual who experience inadequate heating are 1.4 percent more likely to experience sleeping problems.

In order to increase the robustness of our tests when employ individual fixed effects in addition to time fixed effects to control for unobservable individual variables. Looking at poor housing conditions as the independent variable, table 6 illustrates that there are no statistically significant relationships between poor housing conditions and specific health measures. Considering the specific housing problems in column (4), (8), (12), and (16) one can only observe statistically significant relationships between ‘dwellings perceived to be too small’ and back problems and between poor indoor air quality and sleeping problems. Respondents indicating that their housing conditions to be ‘too small’ are 1.5 percent more likely to

experience back problems. Next to that, respondents indicating they experience poor air quality are 2.1 percent more likely to experience sleeping problems.

5.4 Robustness: Excluding movers

Individuals who have changed residency have so far been included in our study. In order to make our findings more robust, the following analyses excludes individuals who have moved during the survey. This is based on the findings of Weinhold (2015) who found that including individuals who have moved during the survey reduces the relationship between housing conditions and health. These findings are based on the suggestion that individuals who have moved during the survey are less exposed to adverse health effects of poor housing conditions. Therefore, individual -and time fixed effects alone do not control for all unobserved variables. This stems from the fact that variation in housing conditions is likely to occur from moving to a new house. However, it might be the case that individuals move from a dwelling which is in good condition to a dwelling which is in poor conditions. This might have the opposite effect on health status.

In order to properly analyse the effect of housing conditions on health, we include an individual-dwelling specific study. Table 7 outlines the effect of housing conditions on the individuals' health within a specific dwelling. The fixed effects control for both individual and dwelling time-invariant characteristics. By excluding individuals who have moved during the survey the sample consists of 21,321 observations. Again the analysis consists of two parts whereby in column (1), (3), (5) and (7) the specific health effects of poor housing conditions are estimated. The second analysis concerns the specific health effects of specific dwelling problems in column (2, 4, 6 and 8). Table 7 is the study's most robust analysis as year-fixed effects, individual-fixed effects and dwelling-fixed effects are included.

Table 7. The relationship between housing conditions and specific health issues for tenants, excluding movers

	(1) Back problems (1=yes)	(2)	(3) Weakness (1=yes)	(4)	(5) Sleeping problems (1=yes)	(6)	(7) Headache (1=yes)	(8)
Poor housing conditions (1=yes)	-0.011		0.0055		0.012		-0.027	
	(-0.66)		(0.32)		(0.74)		(-1.73)	
Too small		0.016		0.012		0.015		-0.018
		(1.24)		(0.92)		(1.19)		(-1.50)
Inadequate heating		-0.012		-0.004		0.009		0.011
		(-0.97)		(-0.29)		(0.78)		(0.96)
Poor air quality		0.012		0.002		0.021*		0.021*
		(0.99)		(0.16)		(1.74)		(1.78)
Practices sports	0.010	0.010	-0.011	-0.011	-0.006	-0.006	-0.001	-0.002
	(1.24)	(1.24)	(-1.28)	(-1.27)	(-0.74)	(-0.74)	(-0.17)	(-0.20)
BMI	0.006***	0.006***	-0.001	-0.001	0.000	0.000	0.002	0.002
	(2.73)	(2.77)	(-0.27)	(-0.25)	(0.08)	(0.11)	(0.93)	(0.94)
Noisy environment	0.017*	0.016*	-0.001	-0.002	0.013	0.011	0.021**	0.018**
	(1.85)	(1.72)	(-0.15)	(-0.16)	(1.47)	(1.20)	(2.40)	(2.10)
Vandalism environment	0.003	0.002	0.021*	0.021*	0.001	0.000	-0.012	-0.013
	(0.23)	(0.15)	(1.84)	(1.82)	(0.05)	(-0.04)	(-1.18)	(-1.26)
_cons	0.373**	0.364*	-0.133	-0.139	0.200	0.183	0.482***	0.480***
	(2.01)	(1.96)	(-0.69)	(-0.72)	(1.13)	(1.02)	(2.80)	(2.79)
Observations	21321	21321	21321	21321	21321	21321	21321	21321
R-squared	0.005	0.005	0.006	0.006	0.005	0.005	0.004	0.004
Socioeconomic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dwelling fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

From table 7 we obtain two striking results namely, the fact that poor indoor air quality has an adverse effect on two specific health issues. The analysis estimates that individuals living in dwellings suffering from poor indoor air quality are 2.1 percent more likely to suffer from sleeping problems as well as from headaches (2.1 percent). This is in line with Bernstein et al (2008), who find that poor air quality has adverse health effects and is especially related to specific health issues such as fatigue and headaches as well as respiratory diseases.

Table 8 outlines the effect of housing conditions on general health measures. In columns (1), (2), (3), (4), (5), and (6) this study analyses the effect of housing conditions on subjective health measures such as health status, health satisfaction and a feeling of depression. Columns (7), (8), (9), (10,) represent the effect of housing conditions on objective health measures. Again, we exclude individuals who have moved during the survey for the same reasons as in table 7.

Table 8. The effect of housing conditions on various health measures for tenants, excluding movers

	(1) Poor health Status (1=yes)	(2)	(3) Health satisfaction (1-10)	(4)	(5) Depression (1-10)	(6)	(7) Number of doctor visits	(8)	(9) Number of days affected	(10)
Poor housing conditions (1=yes)	0.016		-0.010*		0.073		0.136		-2.145	
	(1.15)		(-1.67)		(1.10)		(0.35)		(-1.22)	
Too small		0.007		0.030		0.070		0.864***		-0.035
		(0.64)		(0.67)		(1.33)		(2.86)		(-0.03)
Inadequate heating		0.010		0.04		0.029		0.201		-0.386
		(0.99)		(0.88)		(0.58)		(0.71)		(-0.30)
Poor air quality		0.020*		-0.022		0.048		-0.117		0.113
		(1.91)		(-0.51)		(0.95)		(-0.40)		(0.09)
Practices sports	-0.029***	-0.029***	0.214***	0.213***	-0.063*	-0.062*	-0.378**	-0.376**	-5.287***	-5.294***
	(-4.43)	(-4.43)	(7.72)	(7.71)	(-1.95)	(-1.95)	(-2.02)	(-2.01)	(-6.27)	(-6.28)
BMI	0.001	0.001	-0.040***	-0.040***	-0.027***	-0.026***	0.006	0.009	-0.262	-0.257
	(0.26)	(0.27)	(-5.11)	(-5.07)	(-2.89)	(-2.87)	(0.11)	(0.16)	(-1.09)	(-1.07)
Noisy environment	0.011	0.009	0.005	0.004	0.073*	0.067*	0.138	0.133	1.524	1.499
	(1.38)	(1.10)	(0.15)	(0.12)	(1.93)	(1.77)	(0.63)	(0.60)	(1.54)	(1.50)
Vandalism environment	0.008	0.007	-0.025	-0.025	0.002	-0.001	0.140	0.139	1.941*	1.928*
	(0.87)	(0.77)	(-0.67)	(-0.65)	(0.04)	(-0.02)	(0.55)	(0.54)	(1.68)	(1.67)
_cons	-0.246	-0.258*	11.26***	11.20***	3.233***	3.170***	0.877	0.161	-2.249	-2.399
	(-1.61)	(-1.68)	(17.51)	(17.39)	(4.35)	(4.26)	(0.20)	(0.04)	(-0.11)	(-0.12)
Observations	21321	21321	21321	21321	21321	21321	21321	21321	21321	21321
R-squared	0.006	0.007	0.026	0.026	0.006	0.006	0.006	0.006	0.009	0.009
Socio-economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dwelling fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

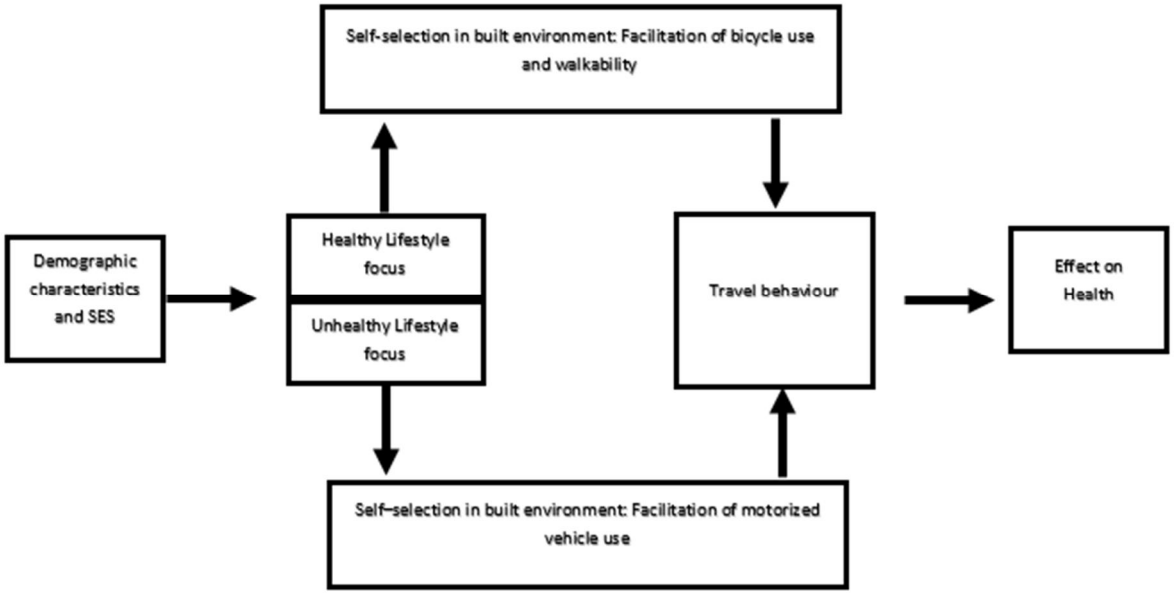
Looking at column (2), this analysis finds a positive relationship between poor indoor air quality and self-assessed health status. This indicates that individuals living in dwellings with poor indoor air quality are two percent more likely to report poor health status. This is again in line with Bernstein et al (2008), who find a strong relationship between outdoor air quality and various health issues.

Next to that, the table above illustrates that individuals living in poor housing conditions score on average 0.1 point lower for health satisfaction on a ten point-Likert scale than individuals living in good housing conditions. However, the most striking finding is depicted in column (8), concerning the effects of dwellings which are perceived to be too small on the number of doctor visits. Individuals living in a dwelling which is too small on average report 0.87 more doctor visits on a yearly basis. This finding is significant at the one percent level and is in line with various studies who highlight the suggestion that overcrowding is likely to occur when a dwelling too small. The Institute of Medicine, (2011) found that health issues arise from closer contact between household members, this includes sleep disruption, lack of privacy, inability to care adequately for sick household members, and increased exposure to the spread of infections. Next to that Easthope et al. (2017) found that the main drivers behind overcrowding are rising housing costs and persistent shortage of affordable housing.

5.5 Self-selection bias in built environment: Empirical evidence on children's health

The study at hand aims to differ from previous literature by controlling for self-selection bias. Aydin et al. (2017) have found a causal significant relationship between the housing environment and health. However, self-selection bias potentially inflates these observed associations. Healthy individuals select residence neighbourhoods based on their preference for health promoting amenities. This self-selection can induce bias that inhibits the establishment of causal relationships between housing conditions and health. To make the concept of self-selection in residential housing and its effect on health more clear this study provides a conceptual framework in which the essence is captured.

Figure 12. Conceptual framework representing an overview of self-selection in residential housing and its effect on public health



Recent studies suggest that both self-selection and built environment are responsible for the travel and activity differences between residents of urban and suburban neighbourhoods (Bagley & Mokhtarian 2002). Therefore, the built environment is considered to be a promoter or disabler for active transportation in the conceptual framework. Demographic characteristics such as age and gender, but also socioeconomic status determine healthy or unhealthy lifestyle preferences. This in terms influences the preferred built environment e.g. people who prefer a healthy lifestyle, would rather chose to live in a built environment promoting walking and bicycle use. Therefore, people self-select them in a preferred built environment. The design of the built environment facilitates or at least allows for the desired travel behaviours. These travel behaviours contribute importantly to a wide range of economic, and health outcomes such as activity and obesity.

Previous literature about residential self-selection is limited however the study conducted by James et al. (2015) tried to capture the magnitude of this. In this study, the authors try to capture the self-selecting bias by looking at pre-move health and post-move neighbourhood features. To examine this, a dataset was used concerning neighbourhood characteristics of female nurses in the United States between 1986 and 2008. In this context, nurses are likely to have more knowledge about health behaviour than the general public. As such, the author expects the potential for self-selection in health promoting built environments to be high in this cohort. They hypothesized that positive associations would exist between pre-move healthy behaviours and 'health-promoting' neighbourhood features, indicating a potential for confounding by residential self-selection in this cohort. In terms of findings, James

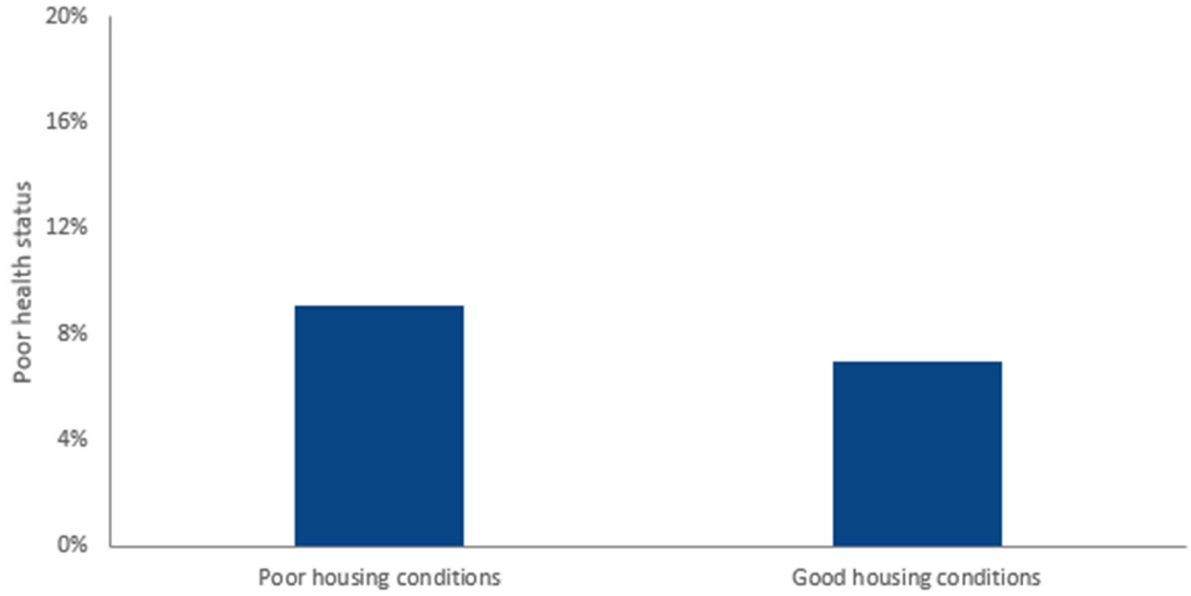
et al. (2015) observed only small associations between health and neighbourhood environment choice observed in this relatively affluent cohort.

5.5.1 Teenagers

In order to control for this self-selection bias this study evaluates the effect of housing conditions on various health measures for teenagers. By excluding all adults in this sub-sample, one is able to establish a relationship without including self-selection bias. This stems from the notion that children or teenagers in this case do not choose where they live. Thereby, this study aims excludes the self-selection bias by analysing a sub-sample concerning teenagers. This study employs two distinct analysis in order to control for self-selection bias and makes a distinction between teenagers and children under the age of fourteen. The reason that these two sub-analyses are distinct from each other has two reasons. First of all, teenagers report about their health status on their own behalf, whereas children under the age of fourteen were assisted by their parents. Next to that, different health measures are employed for children than for teenagers. This comes from the fact that the questionnaire for teenagers and adults differs from the questionnaire targeting children.

Figure 13 depicts the health status of teenagers (aged 13 to 18) in different housing conditions. The first and second column show the percentage of teenagers reporting poor health status according to their housing conditions. 9.1 Percent of the teenagers living in poor housing conditions report poor health status whereas 7.0 percent of the teenagers living in good housing conditions report poor health status.

Figure 13. Percentage of poor health status of teenagers in different housing conditions



In the table below, the effect of housing conditions on teenager's reported health is estimated. Although there is no significant relationship to be found between housing conditions and the number of doctor visits and self-assessed health status, we obtain interesting results.

Table 9. The effect of housing conditions on the number of doctor visits and self-assessed health for teenagers

	(1) Poor health status (1=yes)	(2)	(3)	(4)	(5)	(6)	(7) Number of doctor visits	(8)	(9)	(10)	(11)	(12)
Poor housing conditions (1=yes)	-0.001	-0.042	-0.043				-0.188	-0.433	-2.021**			
	(0.967)	(0.208)	(0.479)				(0.677)	(0.532)	(0.030)			
Too small				0.011	0.041	0.031				0.682**	0.815	1.547**
				(0.523)	(0.118)	(0.531)				(0.027)	(0.129)	(0.040)
Inadequate heating				0.007	0.005	0.074				-0.155	-0.362	-1.093
				(0.722)	(0.874)	(0.124)				(0.697)	(0.550)	(0.132)
Poor air quality				0.004	-0.015	0.007				0.001	-0.577	-0.464
				(0.818)	(0.609)	(0.902)				(0.998)	(0.337)	(0.592)
Sports	-0.011	0.003	0.089**	-0.011	0.001	0.089**	-0.181	-0.295	0.088	-0.228	-0.326	0.146
	(0.494)	(0.899)	(0.027)	(0.488)	(0.953)	(0.026)	(0.543)	(0.491)	(0.884)	(0.444)	(0.447)	(0.809)
BMI	0.005**	0.004	0.007	0.005**	0.004	0.007	0.134***	0.021	-0.147	0.137***	-0.022	-0.129
	(0.048)	(0.380)	(0.430)	(0.046)	(0.396)	(0.445)	(0.001)	(0.828)	(0.276)	(0.001)	(0.826)	(0.343)
Noisy environment	0.038***	0.049**	0.010	0.037**	0.050**	0.011	-0.109	0.035	0.583	-0.136	0.001	0.390
	(0.007)	(0.021)	(0.812)	(0.013)	(0.021)	(0.785)	(0.681)	(0.936)	(0.320)	(0.627)	(0.998)	(0.523)
Vandalism environment	-0.030	0.068***	-0.096*	-0.030	0.070***	-0.095*	0.136	0.031	-1.079	0.129	-0.055	-1.165
	(0.109)	(0.010)	(0.091)	(0.102)	(0.008)	(0.092)	(0.695)	(0.955)	(0.209)	(0.713)	(0.920)	(0.175)
_cons	-0.183	-0.668	-1.059	-0.201	-0.832	-1.53*	-3.70	15.62	37.98***	-4.530	14.55	28.30**
	(0.372)	(0.269)	(0.259)	(0.330)	(0.166)	(0.098)	(0.312)	(0.211)	(0.008)	(0.219)	(0.241)	(0.044)
Observations	1872	1872	467	1872	1872	467	1872	1872	467	1872	1872	467
R-squared	0.017	0.038	0.13	0.017	0.039	0.138	0.007	0.019	0.125	0.009	0.022	0.131
Socio-economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed-effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Dwelling fixed-effect	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes

p-value in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Only considering the time- and individual fixed effect results, there may be several underlying reasons for the insignificant relationship between housing conditions and self-assessed health for teenagers. In terms of sample size, the sub-sample considering teenagers only includes 1,872 individual observations across different waves. As table 10 below indicates, there are only 252 individual observations of teenagers living in poor housing conditions. As shown in figure 13, only 9.1 percent of these teenagers living in poor housing conditions report poor health status, this amounts to only 23 teenagers. Next to that, teenagers might interpret questions regarding health status different than adults. One can imagine that an individual aged fourteen responds differently to the same question than someone in his fifties. Especially, if a teenager feels in a certain way, he or she is not supposed to feel at his/her age. According to the lifetime cycle, teenagers should report better health than adults and consequently should feel better than adults. So, for example, if a teenagers does not feel well, while his/hers peers do, he or she might report a better health status than actually is the case. Although, teenagers report self-assessed health status independently, most of the time parents still decide whether teenagers visit a doctor or not. Furthermore, children age thirteen or older do not spend as much time indoors as infants and are therefore less exposed to the indoor housing conditions In conclusion, one could argue that there are multiple factors that influence underreporting of poor health status among teenagers. Columns (3), (6), (9), and (12) exclude teenagers who moved during the survey and control for dwelling-fixed effect. As table 9 above outlines, the sample used in the analysis appears to be very limited (467 individual observations). This is likely to be the reason the significantly negative relationship between poor housing conditions and the number of doctor visits.

Table 10. Frequency table housing conditions and health status

		Poor health status (1=yes)		Total
		0	1	
Poor housing conditions (1=yes)	0	2,422	182	2,604
	1	226	23	249
	Total	2,648	205	2,853

5.5.2 Children

The second sub-sample includes children below the age of fourteen. This sub-sample concerning children includes 15,780 individual observations and 3,600 children across different waves. It may be interesting to evaluate children's health in relation to housing conditions as younger children are believed to be more susceptible to health issues than adults. Multiple studies report that, children, particularly young children, spend most of their time indoor. In this light, children may be more vulnerable to the effects of poor housing conditions. Figure 14 depicts the percentage of children reporting health issues. This metric is different from general health status in the sense that this health measure is binary indicating whether or not an individual has health problems. 5.3 Percent of the parents living in in poor housing conditions indicate that their children suffer from a poor health status, whereas only 2.4 of the parents living in good conditions do.

Figure 14. Percentage of children suffering from health problems in relation to housing conditions

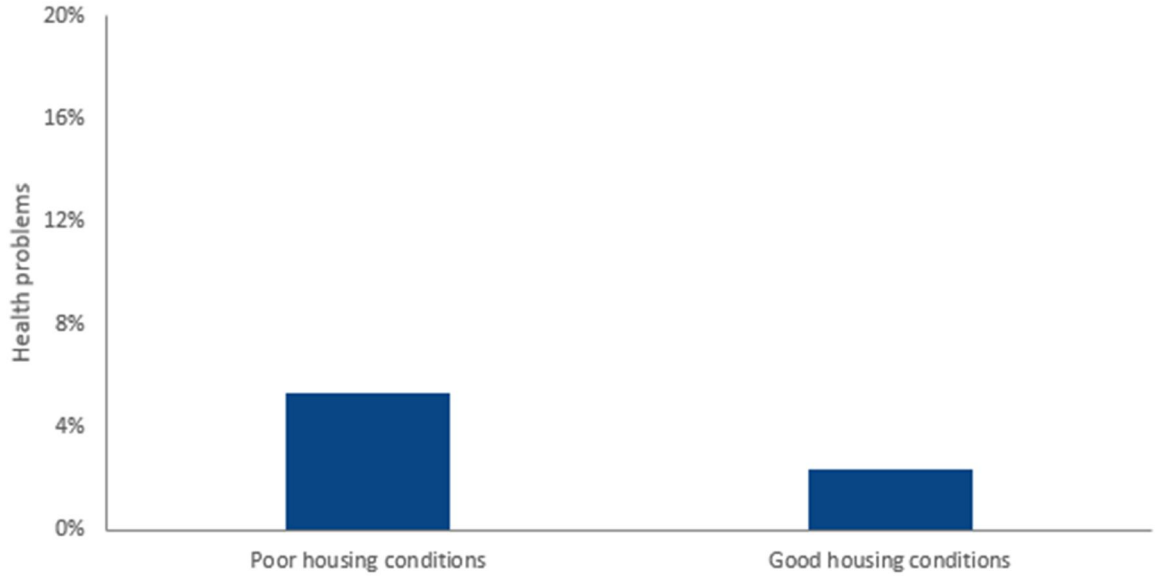


Figure 15 (below) compares the number of days affected between adults and children according to housing conditions. For the second sub-sample regarding children under the age of fourteen, only two health measures are included in the questionnaire. The number of days affected is the only health measure which is included in both surveys. By comparing this metric between adults and children one can observe that adults are more affected by health problems than children. This is terms strokes with the life cycle theory, which suggest that as the time of death approaches throughout the lifecycle the fraction of time spent sick increases.

Figure 15. Numbers of days affected in relation to housing conditions for children

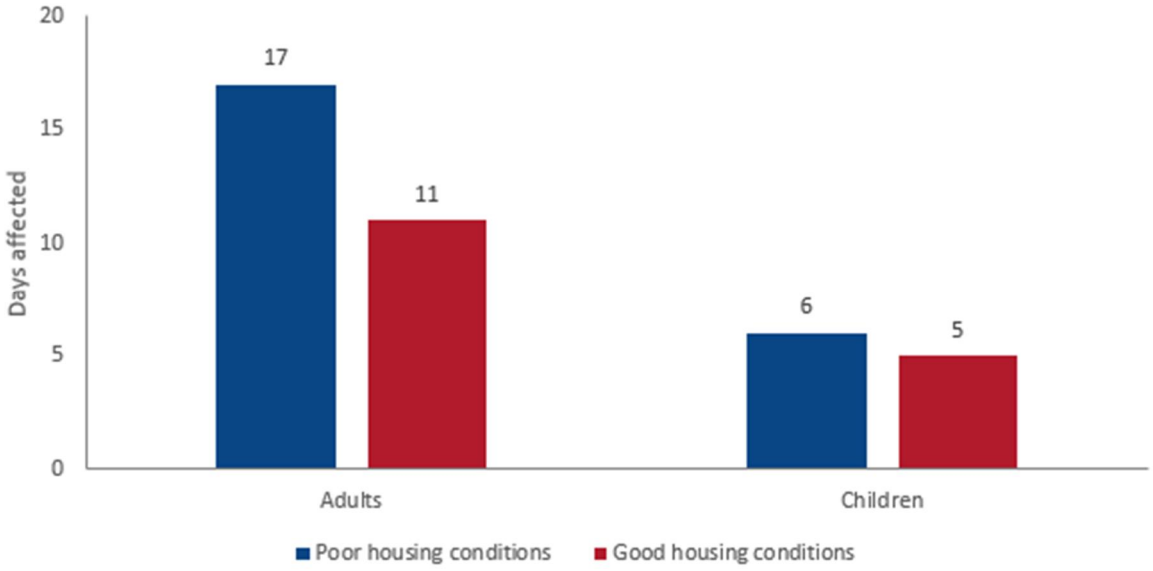


Table 11 illustrates the results of estimating the effect of poor housing conditions on the two health measures regarding children below the age of fourteen. Socioeconomic variables such as age, gender, income and rent are included, while other control variables stemming from socioeconomic nature, such as occupation, civil status and level of education (attended tertiary education or not) are irrelevant for this sub-sample. Furthermore, the sub-sample controls for certain housing and environmental characteristics such as the number of rooms, whether they live in an apartment or not, neighbourhood noise and neighbourhood vandalism.

From table 11 one can conclude that there is indeed a significant relationship between housing conditions and health (only when time fixed effects are excluded). If time fixed effects are excluded, table 11 reports that children living in poor housing conditions are two percent more likely to experience health problems, than children living in good housing conditions. This finding is significant at the one percent level. In our most robust analysis (including time-fixed effects and individual-fixed effects), the results estimate that children living in a dwelling which are perceived as being “too small” are likely to suffer one day more from health issues annually. Next to that, the analysis also finds a significant positive relationship between living in a noisy environment and the number of days affected by health issues. Children living in a noisy neighbourhood are likely to report 2.2 more days affected.

Table 11. The effect of housing conditions on children's health status and the number of days suffered

	(1) Poor health status (1=yes)	(2)	(3)	(4)	(5)	(6)	(7) Number of days suffered	(8)	(9)	(10)	(11)	(12)
Poor housing conditions (1=yes)	0.000	0.020***	-0.008				-0.017	-0.227	-0.300			
	(0.02)	(3.80)	(-1.51)				(-0.03)	(-0.39)	(-0.49)			
Too small				0.004	0.002	0.002				1.045***	1.144***	0.992***
				(1.16)	(0.58)	(0.63)				(2.89)	(2.67)	(2.31)
Inadequate heating				-0.002	-0.003	-0.003				-0.468	-0.736	-0.824
				(-0.41)	(-0.62)	(-0.67)				(-0.98)	(-1.35)	(-1.51)
Poor air quality				-0.004	-0.004	-0.002				0.726	0.745	0.768
				(-0.92)	(-0.85)	(-0.49)				(1.54)	(1.35)	(1.39)
Age	0.002***	0.000	-0.028	0.002***	0.000	-0.025	-0.002	0.042	-2.184	0.002	0.047	-1.339
	(4.38)	(-0.29)	(-0.15)	(4.42)	(-0.48)	(-0.13)	(-0.04)	(0.76)	(-0.10)	(-0.06)	(0.84)	(-0.06)
Gender	-0.012*	0	0	-0.012*	0	0	-0.816	0	0	-0.846	0	0
	(-2.34)	(.)	(.)	(-2.36)	(.)	(.)	(-1.69)	(.)	(.)	(-1.75)	(.)	(.)
Log rent	-0.003	-0.003	-0.003	-0.003	-0.004	-0.002	-0.087	-0.066	0.017	0.106	0.177	0.234
	(-0.63)	(-0.45)	(-0.44)	(-0.51)	(-0.65)	(-0.30)	(-0.16)	(-0.09)	(0.02)	(0.20)	(0.24)	(0.31)
Log income	-0.004	-0.006	0.001	-0.004	-0.006	-0.001	-0.135	-0.594	-0.551	-0.230	-0.653	-0.609
	(-0.89)	(-1.11)	(-0.17)	(-0.97)	(-1.11)	(-0.23)	(-0.31)	(-1.01)	(-0.94)	(-0.53)	(-1.12)	(-1.04)
Number of person in household	-0.003	0.001	-0.004	-0.003	0.000	-0.004	0.232	0.990**	0.965*	0.135	0.867*	0.860*
	(-1.30)	(0.26)	(-1.17)	(-1.47)	(0.03)	(-1.20)	(1.06)	(2.65)	(2.58)	(0.61)	(2.30)	(2.28)
Apartment	-0.006	-0.007	-0.006	-0.007	-0.006	-0.007	-0.065	-0.319	-0.536	-0.196	-0.523	-0.717
	(-1.46)	(-0.89)	(-0.89)	(-1.56)	(-0.91)	(-0.98)	(-0.13)	(-0.39)	(-0.65)	(-0.40)	(-0.63)	(-0.87)
Number of rooms	0.000	-0.002	-0.002	0.000	-0.002	-0.002	-0.026	-0.199	-0.271	0.066	-0.010	-0.182
	(-0.18)	(-0.99)	(-0.98)	(0.04)	(-0.94)	(-0.84)	(-0.16)	(-0.86)	(-1.16)	(0.41)	(-0.41)	(-0.77)
Noisy environment	0.003	-0.001	0.000	0.003	0.000	0.001	1.174***	1.209***	1.194***	0.989***	1.072**	1.062**
	(0.82)	(-0.28)	(0.08)	(0.99)	(-0.09)	(0.16)	(3.30)	(2.85)	(2.81)	(2.68)	(2.48)	(2.45)
Vandalism environment	-0.005	0.008*	-0.007	-0.004	-0.008*	-0.007	0.0203	-0.102	-0.154	-0.034	-0.136	-0.187
	(-1.11)	(-1.80)	(-1.44)	(-1.05)	(-1.68)	(-1.45)	(0.05)	(-0.20)	(-0.30)	(-0.07)	(-0.26)	(-0.36)
_cons	0.200***	0.126*	0.139	0.200***	0.141*	0.136	6.973	8.827	5.666	6.476	7.585	5.533
	(4.01)	(1.75)	(0.63)	(4.01)	(1.96)	(0.62)	(1.33)	(1.11)	(0.22)	(1.24)	(0.95)	(0.22)
Observations	15870	15870	15870	15870	15870	15870	15870	15870	15870	15870	15870	15870
R-squared	0.061	0.001	0.061	0.061	0.001	0.062	0.007	0.001	0.007	0.007	0.002	0.008
Socio-economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes
Individual fixed-effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Dwelling fixed-effects	No	No	No	No	No	No	No	No	No	No	No	No

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

However, it should be noted that the behavioural control variables such as BMI and whether a child practises sports are not included. The reason for this is lack of data about children height and weight and therefore this study is not able to construct a BMI variable. According to the World Health Organization seven percent of boys and 4.6 percent of girls are perceived to be obese in Switzerland, which is relatively low compared to other high-income countries. The percent of children in the US that is obese amounts to 23.3 percent for boys and 19.5 percent for girls. In Germany this is eleven percent and seven percent respectively. This still indicates that the findings in table 11 might be inflated as their BMI is not taken into account. However, in the analysis regarding the health effect of housing conditions for teenagers, no statistically significant relationship between BMI and self-assessed health status is established, but this might be due to the fact that the observations in this sample are limited. Next to that, it is very likely that parents are not able to adequately report their children's health status. In order to make the study about the relationship between children's health and housing conditions more conclusive, further research would need to include behavioural characteristics (BMI and Sports) regarding children. Especially as obesity in high income countries such as Switzerland is on the rise.

6. Discussion and conclusion

This section discusses the results obtained in section 5, which included multiple analyses on the relationship between housing conditions and health. The results showed evidence for a causal relationship between housing conditions and health and are in line with our theoretical framework. In the following section, this study discusses multiple implications of the results as well as limitations. Furthermore, the validity of our study will be discussed and recommendations for future research will be posed.

6.1 Health effects of housing conditions

The results concerning self-assessed health measures indicate a strong relation between housing conditions and health. In general this study found multiple causal results concerning the health effects of housing. First of all, this study estimated the effect of poor housing conditions on subjective health measures and outlined that or tenants in general, living in poor housing conditions has adverse consequences for their health status, health satisfaction and likelihood of facing mental illness. Moreover, in the most robust analysis this study finds that poor indoor air quality leads to sleeping problems as well as headaches. Furthermore, this study supports and validates previous research by finding causal significant relationships between

subjective health measures and the external environment. Specifically, we establish a significantly positive relationship between environmental noise and the likelihood of depression, which is in line with the findings of Weinhold et al. (2015). Next to that, the study at hand estimated the effect of housing conditions on healthcare demand, through the yearly number of doctor visits. Strikingly the estimates indicate a significantly positive relationship between poor housing conditions and the number of doctor visits. However, the most notable and robust finding refers to the negative health effect of dwellings which are perceived to be too small. The results estimate that individuals living in a dwelling which is perceived to be too small report 0.8 more doctor visits yearly.

6.2 Robustness checks

The robustness of our analysis is of major importance in our contribution to academic literature. Especially, as this study uses data retrieved over a period of eighteen years. Implicating that over time that the changes in housing conditions over time are accompanied with other changes in either life conditions or preferences of individuals. Unobserved variables such as higher interest rates or other macro-economic shocks may affect the strength and causality of the relationship between housing conditions and health. Next to that, unobserved individual changes might also affect this relationship when for example an individual chooses to cuts back on healthy food. As outlined before, human decision making influences the demand of healthcare. As Bagley & Mokhtarian (2002) point out, people who have less knowledge about health or are less interest in are making less investments in health and may choose to live in less healthy environments. This distorts the strength of the relationship between housing conditions and health.

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, this study employed multiple robustness analyses. First of all, time fixed effects and individual fixed effects are employed and our most robust analyses includes dwelling fixed as well by excluding individuals who have moved during the survey. Nevertheless, the occurrence of self-selection bias might still be prevalent in the analysis. In order to overcome self-selection bias we employed a different analysis focusing on children, who do not have any decision authority in selecting the dwelling in which he or she lives. By estimating the health effects of housing conditions on children one is able to exclude self-selection bias from the sample. In general, we found that on children living in poor housing conditions are report one additional doctor visit yearly than children living in good housing conditions as a result of living in a

dwelling which is perceived to be too small. Portraying the similar analysis on adults we obtained similar results.

6.3 Economization of excess healthcare demand

The study's most notable contribution to academic literature is the fact that a significantly positive relationship is found in our most robust analysis between dwellings which are perceived to be too small and the number of doctor visits. As outlined before, overcrowding is the reason behind this causal relationship. According to the Institute of Medicine (2011) health issues arise from closer contact between household members. Table 8 estimated that an individual living in a dwelling which is perceived to be too small reports 0.87 more doctor visits yearly. The fact that individuals are living in dwellings which are too small is a direct effect of the Swiss rental housing market. Figure 4 outlines the overburden-rate, illustrating that 40 percent of the lowest incomes in Switzerland pay over 40 percent of their income on rent. Therefore one could conclude that supply of affordable housing for individuals in the lowest income quintile is limited. In addition, the Swiss housing market is characterized by the laws of supply and demand and social housing is underdeveloped. This is in line with Easthope et al. (2017) who found that the main drivers behind overcrowding are rising housing costs and persistent shortage of affordable housing.

The following section attempts to estimate the burden on the total healthcare bill. In order to economize the costs of excess healthcare demand as a result of overcrowded households, multiple parameters are needed. Table 2 outlines that 14.52 percent of the total households who rent their dwelling report that their dwelling is too small. From our analysis we estimated that the individuals living in these dwellings report 0.87 more doctor visits. Next to that, Switzerland has lowest rate of home ownership in the World. This implies that 38 percent of the Swiss population lives in rental dwellings. By multiplying the total amount of Swiss individuals living in rental dwellings times the percent living in dwelling which are perceived to be too small, one is able to estimate the total size of the population which report 0.87 excess doctor visits yearly. The only unknown parameter is the costs of doctor visits. Therefore the equation can be described as follows:

*Percent of the population living in rental dwellings (62 percent) * Percent living in dwellings which are perceived to be too small (14.52 percent) * total Swiss population (8.577 million according to OECD. Stat 2018) * number of excess doctor visits (0.87) * costs of doctor visit*

*(0.62 * 0.1452 * 8.577million * 0.87) * cost of doctor visit*

*(672,000) * cost of doctor visit*

6.4 Validity

It is of importance to judge the validity of this study by determining internal and external validity separately. Internal validity refers to the degree to which the results are attributable to the independent variable, whereas external validity refers to the extent to which the results of this study can be generalized.

6.4.1 Internal validity

According to Campbell and Stanley (1960) internal validity refers to the extent to which the methodological research design used by a researcher can provide empirical evidence to test the possible causal relationship between the independent variable and the dependent variable. Without internal validity, this study may offer causal results between independent and dependent variables in their data based on speculation. In order to control for internal validity this study employed fixed effects. This study employed a Hausmann which identified that fixed effects should be incorporated in the study as the unique errors are correlated with the regressors. Next to that, a sub-sample regarding children was used in order to overcome the problem of self-selection bias. By including a study regarding children, this study extended previous research regarding the effect of poor indoor housing conditions on health. Bagley & Mokhtarian (2002) argued that individuals will self-select them in residence neighbourhoods based on their preference for health promoting or health diminishing amenities. This self-selection can induce bias that inhibits the establishment of causal relationships between neighbourhood factors and health outcomes. The creation of this specific sub-sample stems for the notion that children are not able to self-select them in poor housing conditions as they do not possess the choosing authority on where they live. By identifying roughly the same results for the sub sample regarding children, as we did for the initial sample we controlled for self-selection bias. However it should be noted that the results regarding our sub-sample only hold

at the ten percent level. Further research might therefore by necessary to strengthen our findings.

6.4.2 External validity

External validity refers to the extent to which the findings of this study can be generalized to the population where the sample is taken from or to other similar populations in terms of contexts, individuals, times, and settings. One way to determine whether external validity is present, is to look at data retrieval. According to Lugtiga, Dasb and Scherpenzeel (2014) sample framing occurs for sampling the general public via the internet. Therefore several research institutions have established online panels that focus on traditional probability samples. In order to overcome problems regarding self-selected panels they contact participants via offline survey methods such as interviews conducted by telephone, hoping to overcome the problem of the low external validity of self-selected panels. The SHP panel that we used in this study addresses this issue by conducting telephone interviews, providing households that could otherwise not participate due to the lack of internet connection. Furthermore, Aydin et al. (2017) used a similar household panel dataset concerning Germany. The tests they ran are similar to those used in the study at hand. This also translates into similar findings regarding the effect of poor housing conditions on various health measures.

6.5 Limitations

This paper is subject to multiple limitations which may or may not distort the causal relationship between housing conditions and health. First of all, the variable 'full-time' is perceived as a binary, either someone is employed or someone is unemployed. No distinction is made between types of work. However, to get a more accurate indication of the effect of occupational status on health, one should disentangle work into multiple categories, which have different explanatory power on the effect of health. Work, whether paid or not, may be interesting and engaging or it can be repetitious and oppressive. These differences may have an effect on health status, which are not captured in this study.

Second, whether someone smokes on a regular basis has proved to affect health. Fielding (1985) reported that among 565,000 annual deaths from coronary heart disease, 170,000 (30 percent) can be attributed to smoking. However, whether someone smokes or not is not included in this study, due to a lack of data. Next to that are not all participants asked to report their BMI (weight and height) and therefore the sample is limited to 39,769 viable observations instead of the maximum viable observations (60,211).

Furthermore, the survey is of subjective nature and does not include a lot variables indicating objective housing conditions. Although, this would increase the robustness of this study, this would be rather difficult to extract from a survey. The solution for this would be a third party opinion from experts, who indicate housing conditions of houses manually. However this would be costly and time consuming. Another possible method to increase the number of objective housing measures in to insert a ranking system in which respondents need to indicate to which extent they face tangible housing problems. From this ranking system experts should be able to indicate whether housing conditions are poor or good.

There are multiple parameters in this study which are debatable. As explained above, multiple indicators influencing the direct effect of housing conditions on health are not properly recognized. It is therefore difficult to indicate to which extent the parameters are correctly influencing the relationship between housing conditions and health.

The academic motivation of this paper is to identify and estimate the impact of health variation due to housing conditions on the healthcare system. The findings of this study estimate that poor housing conditions results into excess healthcare demand. However, it seems highly unlikely that this will provoke action from governments or municipalities to increase affordable and better housing and install stricter tenancy laws. The reason for this is that the scope of this paper is too narrow, as it focuses solely on the costs excess healthcare demand. It should be noted however that increased suffering from health issues due to housing conditions might also lead to higher absenteeism, chronic illness and work disability which increases the costs on society extensively.

In order to evaluate the robustness of the analysis, this paper applied a similar analysis on a different dataset concerning the health status of children. The findings suggest that the analysis is relatively robust as similar results are obtained for children as for adults. However, it is difficult to be conclusive about this as the survey regarding children as it uses slightly different health metrics than the survey regarding adults. Next to that, the survey concerning children is filled in by the parents as children of young age are unable to indicate whether they feel well or not. This might give a distorted view as parents may not indicate the well-being of their children correctly. This can only be solved if more objective measures of health status are included in the children's survey.

Future research can build on the findings and limitations of this thesis in order to identify the exact causal relationship between housing conditions and health issues in order to estimate excess healthcare costs as a result from poor housing conditions. Furthermore, the scope of future research should be broadened and aimed at estimating total costs of poor

housing conditions on society as a whole. This is the only viable way to provoke governments and municipalities to increase affordable and better housing as well as stricter tenancy laws.

6.6 Conclusion

In multiple high-income countries, the number of elderly grows, putting a strain on the healthcare system, while the nonelderly population is decreasing, resulting in a severe shortage of direct caregivers. These projected trends are fundamental to the biggest problem in healthcare: Affordability. By identifying sources of health deprivation and simultaneously healthcare demand, potential measures to resolve and dampen the affordability problem can be put into place. Previous studies have identified three domains of determinants of health variation namely, individual behavioural characteristics such as unhealthy eating and no exercise, the external environment and socioeconomic status. However, one of the least studied topics concerns the effect of the housing conditions on public health. The indoor environment and housing conditions are considered to affect productivity, absenteeism, health and comfort.

This study contributed to the existing but limited research on the relationship between housing conditions and health by analysing the potential causal relation between rental housing conditions and occupant health. This is done by analysing a longitudinal dataset including 39,769 observations of individuals living in rental dwellings over a time-span of eighteen years. The Swiss Household Panel (SHP) used in this study is retrieved from the FORS database and is based on a random sample. The analysis finds that individuals living in poor housing conditions visit the doctor 0.5 more often than individuals living in good housing conditions. Furthermore, this paper finds that respondents who report poor indoor air quality are two percent more likely to experience poor health status. Regarding specific health issues, this study finds that respondents indicating their housing conditions to be ‘too small’ are 1.5 percent more likely to experience back problems. Next to that, respondents indicating they experience poor air quality are 2.1 percent more likely to experience sleeping problems. Next to the fact that this study controls for multiple factors which distort the causal relationship between housing conditions and health, this study employs fixed effects to control for unobserved variables.

In order to make our findings more robust, the analyses excludes individuals who have moved during the survey. The results show that individuals living in dwellings which are too small on average report 0.87 more doctor visits on a yearly basis. This finding is significant at the one percent level and is in line with various studies who highlight the suggestion that overcrowding is likely to occur when a dwelling is perceived to be too small.

However, self-selection bias potentially inflates these observed associations. Therefore, this study employs a second dataset regarding children aged below thirteen. This subsample includes 15,870 unique observations spread over 18 years representing 3,600 unique individuals. The findings suggest that children living in housing conditions which are perceived as being “too small” are likely to suffer one day more from health issues per year. This strikes with the results of the analysis regarding adults. Next to that, the analysis also finds that children living in a noisy neighbourhood are likely to report 2.2 more days affected by health issues. These findings are economized in order to estimate the impact of this findings on the healthcare system. The results show that the total number of additional doctor visits in Switzerland due to houses being ‘too small’ lies around 672,000 doctor visits annually.

Reference list

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

Akgüç, M. (2011). *The Effects of Different Stages of Education on Income across Countries*. Working paper, Toulouse School of Economics (TSE).

Antonovsky, A. (1967). Social Class, Life Expectancy and Overall Mortality. The Milbank Memorial Fund Quarterly, 45(2), pp. 31-73.

Aydin, E., Eichholtz, P., Kok, N., & Palacios, J. (2017). On the Economics of Health in Homes.

Bagley, M. N., & Mokhtarian, P. L. (2002). The impact of residential neighborhood type on travel behavior: A structural equations modeling approach. *The Annals of regional science*, *36*(2), 279-297.

Basner, M., & McGuire, S. (2018). WHO environmental noise guidelines for the European Region: a systematic review on environmental noise and effects on sleep. *International journal of environmental research and public health*, *15*(3), 519.

Barker, D. J. P., Coggon, D., Osmond, C., & Wickham, C. (1990). Poor housing in childhood and high rates of stomach cancer in England and Wales. British Journal of Cancer, 61(4), 575

Becker, G. (1964). Human Capital. In N. B. Research. New York: Columbia University Press.

Becker, G. (1967). Human Capital and the Personal Distribution of Income: An Analytical Approach.

Becker, G. (1975). Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education. New York: NBER.

Bennett, D. H., Margni, M. D., McKone, T. E., & Jolliet, O. (2002). Intake fraction for multimedia pollutants: a tool for life cycle analysis and comparative risk assessment. *Risk Analysis: an international journal*, 22(5), 905-918.

Benzeval, M., & Judge, K. (2001). Income and health: the time dimension. Social Science & Medicine, 52(9), 1371-1390.

Bertakis, K., Azari, R., Helms, L., Callahan, E., & Robbins, J. (2000). Gender differences in the utilization of health care services. The Journal of Family Practice, 49(2), 147-152.

Bilger, M., & Carrieri, V. (2013). Health in the cities: when the neighbourhood matters more than income. Journal of Health Economics, 32(1), 1-11.

Bird, C. E., & Fremont, A. M. (1991). Gender, time use, and health. *Journal of Health and social Behavior*, 114-129.

Bonnefoy, X., Braubach, M., Davidson, M., & Robbel, N. (2007). A pan-European housing and health survey: description and evaluation of methods and approaches. *International Journal of Environment and Pollution*, *30*(3-4), 363-383.

Bourassa, S. C., & Hoesli, M. (2010). Why do the Swiss rent?. *The Journal of Real Estate Finance and Economics*, *40*(3), 286-309.

Britten, N., Davies, J. M., & Colley, J. R. (1987). Early respiratory experience and subsequent cough and peak expiratory flow rate in 36 year old men and women. *Br Med J (Clin Res Ed)*, *294*(6583), 1317-1320.

Britten, R. H. (1938). Housing and Health. American Journal of Public Health, 28, 957-960.

Blinder, A. S., & Weiss, Y. (1976). Human capital and labor supply: A synthesis. *Journal of Political Economy*, *84*(3), 449-472.

Campbell, D. T., & Stanley, J. C. (2015). *Experimental and quasi-experimental designs for research*. Ravenio Books.

Chadwick, E. (1843). *Report on the Sanitary Condition of the Labouring Population Og Great: Britain: Supplementary Report on the Results of Special Inquiry Into the Practice of Interment in Towns* (Vol. 2). HM Stationery Office.

Cohen Hubal, E. A., Sheldon, L. S., Burke, J. M., McCurdy, T. R., Berry, M. R., Rigas, M. L. & Freeman, N. C. (2000). Children's exposure assessment: a review of factors influencing Children's exposure, and the data available to characterize and assess that exposure. *Environmental health perspectives*, *108*(6), 475-486.

Conger, R. D., & Elder Jr, G. H. (1994). Families in troubled times: The Iowa youth and families project. *Families in troubled times: Adapting to change in rural America*, 3-19.

Contoyannis, P., Jones, A., & Rice, N. (2004). The Dynamics of Health in the British Household Panel Survey. Journal of Applied Econometrics, 19, 473-503.

Cutler, D., & Lleras-Muney, A. (2006). Education and Health: Evaluating Theories and Evidence. NBER Working Paper No. 12352, The National Bureau of Economic Research.

Daley, C., Gubb, J., Clarke, E., & Bidgood, E. (2013). Healthcare Systems: The Netherlands. *London: Civitas Health Unit.*

Darmon, N., & Drewnowski, A. (2008). Does social class predict diet quality?–. *The American journal of clinical nutrition*, *87*(5), 1107-1117.

Duflo, E., Greenstone, M., & Hanna, R. (2008). Indoor Air Pollution, Health and Economic Well-being. 1(1). Retrieved from http://sapiens.revues.org/130

Easthope, H., Stone, W., & Cheshire, L. (2018). The decline of 'advantageous disadvantage' in gateway suburbs in Australia: The challenge of private housing market settlement for newly arrived migrants. *Urban Studies*, *55*(9), 1904-1923.

Fagan, P., Shavers, V., Lawrence, D., Gibson, J. T., & Ponder, P. (2007). Cigarette smoking and quitting behaviours among unemployed adults in the United States. *Nicotine & Tobacco Research*, *9*(2), 241-248.

Faustman, E. M., Silbernagel, S. M., Fenske, R. A., Burbacher, T. M., & Ponce, R. A. (2000). Mechanisms underlying Children's susceptibility to environmental toxicants. *Environmental health perspectives*, *108*

Fielding, J. E. (1985). Smoking: health effects and control. *New England journal of medicine*, *313*(9), 555-561.

GBD 2015 Obesity Collaborators. (2017). Health effects of overweight and obesity in 195 countries over 25 years. *New England Journal of Medicine*, *377*(1), 13-27.

Gerstel, N., Riessman, C. K., & Rosenfield, S. (1985). Explaining the symptomatology of separated and divorced women and men: The role of material conditions and social networks. *Social forces*, *64*(1), 84-101.

Glaser, M. (2017). The situation of social housing in Switzerland. *Critical Housing Analysis*, *4*(1), 72-80.

Goldman, N. (2001). Social inequalities in health. *Annals of the New York Academy of Sciences*, *954*(1), 118-139.

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

Hammer, M. S., Swinburn, T. K., & Neitzel, R. L. (2013). Environmental noise pollution in the United States: developing an effective public health response. *Environmental health perspectives*, *122*(2), 115-119.

Hood, E. (2005). Dwelling Disparities: How Poor Housing Leads to Poor Health. *Environmental Health Perspective*, 113(5), 310-317.

James, P., Hart, J. E., Arcaya, M. C., Feskanich, D., Laden, F., & Subramanian, S. V. (2015). Neighborhood self-selection: the role of pre-move health factors on the built and socioeconomic environment. *International journal of environmental research and public health*, *12*(10), 12489-12504.

Klepeis, N., Nelson, W., Ott, W., Robinson, J., Tsanh, A., Switzer, P., . . . Engelmann, W.

(2001). The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. *Journal of Exposure Analysis and Environmental Epidemiology,* 11, 231–252.

Kling, J. R., Liebman, J. B., & Katz, L. F. (2007). Experimental analysis of neighborhood effects. *Econometrica*, *75*(1), 83-119.

Lechner, M. (2009). Long-run labour market and health effects of individual sports activities. *Journal of Health Economics*, *28*(4), 839-854.

Lleras-Muney, A. (2005). The Relationship Between Education and Adult Mortality in the United States. *Review of Economic Studies*, 72, 189-221.

Lugtig, P., Das, M., & Scherpenzeel, A. (2014). Nonresponse and attrition in a probability-based online panel for the general population.

Macintyre, S., Ellaway, A., Hiscock, R., Kearns, A., Der, G., & McKay, L. (2003). What features of the home and the area might help to explain observed relationships between housing tenure and health? Evidence from the west of Scotland. *Health & Place*, *9*(3), 207-218.

Macintyre, S., Ellaway, A., Der, G., Ford, G., & Hunt, K. (1998). Do housing tenure and car access predict health because they are simply markers of income or self-esteem? A Scottish study. *Journal of Epidemiology & Community Health*, *52*(10), 657-664.

McGregor, M. (1963). Housing and Health. Public Health, 77(2), 72-81.

Montgomery, S. M., Bartley, M. J., Cook, D. G., & Wadsworth, M. E. (1996). Health and social precursors of unemployment in young men in Great Britain. *Journal of Epidemiology & Community Health*, *50*(4), 415-422.

Mossakowski, K. N. (2008). Is the duration of poverty and unemployment a risk factor for heavy drinking? *Social science & medicine*, *67*(6), 947-955.

Mirowsky, J., & Ross, C. (1998). Education, Personal Control, Lifestyle and Health: A Human Capital Hypothesis. *Research on Aging, 20*(4), 415-449.

Mushkin, S. (1962). Health as an Investment. J.P.E., 70(2), 129-157.

Nazaroff, W. (2008). Inhalation intake fraction of pollutants from episodic indoor emissions. *Building and Environment*, *43*(3), 269-277.

Neidell, M. (2004). Air pollution, health, and socio-economic status: the effect of outdoor air quality on childhood asthma. *Journal of Health Economics, 23*(6), 1209-1236.

Niemann, H., Bonnefoy, X., Braubach, M., Hecht, K., Maschke, C., Rodrigues, C., & Robbel, N. (2006). Noise-induced annoyance and morbidity results from the pan-European LARES study. *Noise and Health, 8*(31), 63.

Ross, C., Mirowsky, J., & Goldsteen, K. (1990). The Impact of the Family on Health: The Decade in Review. *Journal of Marriage and the Family, 52*(4), 1059-1078.

Roy, A. (1950). The Distribution of Earnings and Individual Output. *Economic Journal*, 60, 489-505.

Schlenker, W., & Walker, W. (2016). Airports, Air pollution, and contemporeaneous Health. *Review of Economic Studies, 83*(2), 768-809.

Schultz, T. (1961). Investment in Human Capital. *The American Economic Review, 51*(1), 1-17.

Schweizer, C., Edwards, R. D., Bayer-Oglesby, L., Gauderman, W. J., Ilacqua, V., Jantunen, M. J., & Künzli, N. (2007). Indoor time–microenvironment–activity patterns in seven regions of Europe. *Journal of Exposure Science and Environmental Epidemiology*, *17*(2), 170.

Schultz, T. W. (1972). Human capital: Policy issues and research opportunities. In *Economic Research: Retrospect and Prospect, Volume 6, Human Resources* (pp. 1-84). NBER.

Smith, K. R. (1988). Air pollution: assessing total exposure in developing countries. *Environment: Science and Policy for Sustainable Development*, *30*(10), 16-35.

Thalmann, P., & Favarger, P. (2002). *Locataire ou propriétaire?: enjeux et mythes de l'accession à la propriété en Suisse*. PPUR presses polytechniques.

The World Bank. (2016). Health expenditure, public (% of GDP).

Urbanos-Garrido, R. M., & Lopez-Valcarcel, B. G. (2015). The influence of the economic crisis on the association between unemployment and health: an empirical analysis for Spain. *The European Journal of Health Economics*, *16*(2), 175-184.

Wagstaff, A. (1986). The demand for health: some new empirical evidence. *Journal of health economics*, *5*(3), 195-233.

Weinhold, D. (2015). Sick of noise: the health effects of loud neighbours and urban din. London: Grantham Research Institute on Climate Change and the Environment. Working Paper no. 213.

WHO. (2017). Health Impact Assessment (HIA): Health inequality and inequity.

Wilkinson, P., Landon, M., Armstrong, B., Stevenson, S., & McKee, M. (2001). *Cold comfort: the social and environmental determinants of excess winter death in England, 1986-1996*. Joseph Rowntree Foundation.

Appendix

Appendix 1. Table 4 full version

	(1) Poor health (1=yes)	(2)	(3)	(4)	(5) Health satisfaction (1-10)	(6)	(7)	(8)	(9) Depression (1-10)	(10)	(11)	(12)
Poor housing conditions (1=yes)	0.0458***	0.0140			-0.212***	-0.117**			0.210***	0.125**		
	(0.000)	(0.135)			(0.000)	(0.003)			(0.000)	(0.006)		
Too small												
			0.0124*	0.00705	-0.0505*	0.00149	-0.0505*	0.00149	0.0657*	0.0321	0.0657*	0.0321
			(0.030)	(0.297)	(0.050)	(0.958)	(0.050)	(0.958)	(0.028)	(0.327)	(0.028)	(0.327)
Inadequate heating												
			0.0265***	0.00795	-0.0545*	0.0108	-0.0545*	0.0108	0.120***	0.0688*	0.120***	0.0688*
			(0.000)	(0.232)	(0.037)	(0.700)	(0.037)	(0.700)	(0.000)	(0.032)	(0.000)	(0.032)
Poor air quality												
			0.0359***	0.0203**	-0.122***	-0.0569	-0.122***	-0.0569	0.142***	0.0698*	0.142***	0.0698*
			(0.000)	(0.004)	(0.000)	(0.055)	(0.000)	(0.055)	(0.000)	(0.041)	(0.000)	(0.041)
Gender	-0.0371***	0	-0.0367***	0	0.162***	0	0.162***	0	-0.579***	0	-0.579***	0
	(0.000)	(.)	(0.000)	(.)	(0.000)	(.)	(0.000)	(.)	(0.000)	(.)	(0.000)	(.)
Age	0.00336***	0.00548***	0.00334***	0.00558***	-0.0152***	-0.0605***	-0.0152***	-0.0605***	0.00411***	0.0174***	0.00411***	0.0174***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Married	-0.0205***	-0.0142	-0.0213***	-0.0148	0.0704*	0.0697	0.0704*	0.0697	-0.170***	-0.147**	-0.170***	-0.147**
	(0.000)	(0.133)	(0.000)	(0.118)	(0.013)	(0.081)	(0.013)	(0.081)	(0.000)	(0.001)	(0.000)	(0.001)
Attended tertiary education	-0.0239***	-0.0170	-0.0249***	-0.0171	-0.0109	-0.0199	-0.0109	-0.0199	0.0166	-0.0292	0.0166	-0.0292
	(0.000)	(0.100)	(0.000)	(0.099)	(0.725)	(0.648)	(0.725)	(0.648)	(0.648)	(0.559)	(0.648)	(0.559)
Works full-time	-0.0316***	-0.00302	-0.0317***	-0.00319	0.110***	0.0234	0.110***	0.0234	-0.170***	-0.123***	-0.170***	-0.123***
	(0.000)	(0.686)	(0.000)	(0.668)	(0.000)	(0.455)	(0.000)	(0.455)	(0.000)	(0.001)	(0.000)	(0.001)
Practices sports	-0.0516***	-0.0293***	-0.0514***	-0.0293***	0.239***	0.174***	0.239***	0.174***	-0.146***	-0.0805***	-0.146***	-0.0805***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log rent	0.00850	0.0128	0.00903	0.0138	-0.0854**	-0.0646	-0.0854**	-0.0646	0.0435	0.0732	0.0435	0.0732
	(0.147)	(0.139)	(0.125)	(0.114)	(0.003)	(0.078)	(0.003)	(0.078)	(0.192)	(0.082)	(0.192)	(0.082)
Log income	-0.0361***	-0.00952	-0.0358***	-0.00941	0.132***	0.0721**	0.132***	0.0721**	-0.248***	-0.146***	-0.248***	-0.146***
	(0.000)	(0.131)	(0.000)	(0.135)	(0.000)	(0.007)	(0.000)	(0.007)	(0.000)	(0.000)	(0.000)	(0.000)
BMI	0.00613***	0.000160	0.00622***	0.000188	-0.0536***	-0.0328***	-0.0536***	-0.0328***	0.000476	-0.0317***	0.000476	-0.0317***
	(0.000)	(0.903)	(0.000)	(0.886)	(0.000)	(0.000)	(0.000)	(0.000)	(0.902)	(0.000)	(0.902)	(0.000)
Number of persons in household	0.00296	-0.00317	0.00203	-0.00373	0.0170	-0.00754	0.0170	-0.00754	0.0197	-0.00855	0.0197	-0.00855
	(0.235)	(0.423)	(0.420)	(0.350)	(0.175)	(0.653)	(0.175)	(0.653)	(0.181)	(0.657)	(0.181)	(0.657)
Lives in Apartment	-0.00171	-0.0109	-0.00324	-0.0113	-0.00782	0.0369	-0.00782	0.0369	0.0412	-0.0217	0.0412	-0.0217
	(0.779)	(0.317)	(0.596)	(0.299)	(0.803)	(0.421)	(0.803)	(0.421)	(0.264)	(0.681)	(0.264)	(0.681)
Number of rooms	-0.00117	0.00455	-0.000548	0.00485*	0.0157*	0.0141	0.0157*	0.0141	0.00288	0.0291*	0.00288	0.0291*
	(0.450)	(0.063)	(0.726)	(0.049)	(0.043)	(0.175)	(0.043)	(0.175)	(0.752)	(0.015)	(0.752)	(0.015)
Noisy environment	0.0185***	0.00830	0.0123**	0.00577	-0.0475*	-0.000516	-0.0475*	-0.000516	0.0913***	0.0340	0.0913***	0.0340
	(0.000)	(0.099)	(0.005)	(0.258)	(0.015)	(0.981)	(0.015)	(0.981)	(0.000)	(0.167)	(0.000)	(0.167)
Vandalism environment	0.0251***	0.00448	0.0219***	0.00321	-0.0422	0.0213	-0.0422	0.0213	0.0672*	0.00147	0.0672*	0.00147
	(0.000)	(0.490)	(0.000)	(0.622)	(0.095)	(0.437)	(0.095)	(0.437)	(0.022)	(0.963)	(0.022)	(0.963)
_cons	0.280***	-0.0357	0.267***	-0.0513	8.841***	10.81***	8.841***	10.81***	4.734***	3.387***	4.734***	3.387***
	(0.000)	(0.689)	(0.000)	(0.567)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	39769	39769	39769	39769	39769	39769	39769	39769	39769	39769	39769	39769
R-squared		0.00444		0.00473		0.0265		0.0263		0.00589		0.00597
P-value	1.04e-317	0	2.47e-323	0	0	0	0	0	5.57e-140	0	1.37e142	0
Socio-economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed-effects	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix 212. Table 5 full version

	(1) Number of doctor visits	(2)	(3)	(4)	(5) Number of days affected	(6)	(7)	(8)
Poor housing conditions (1=yes)	1.016***	0.514*			2.101*	-0.900		
	(0.000)	(0.036)			(0.038)	(0.439)		
Too small			0.549***	0.414*			0.447	-0.533
			(0.000)	(0.020)			(0.534)	(0.526)
Inadequate heating			0.463**	0.340			0.990	-0.0572
			(0.003)	(0.052)			(0.179)	(0.945)
Poor air quality			0.0802	-0.125			1.628*	0.942
			(0.614)	(0.500)			(0.031)	(0.284)
Gender	-1.313***	0	-1.305***	0	-0.635	0	-0.616	0
	(0.000)	(.)	(0.000)	(.)	(0.405)	(.)	(0.420)	(.)
Age	0.0407***	0.115***	0.0410***	0.118***	0.118***	0.820***	0.116***	0.819***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Married	0.109	0.277	0.0824	0.244	-0.568	-0.101	-0.601	-0.0640
	(0.473)	(0.265)	(0.588)	(0.328)	(0.435)	(0.932)	(0.410)	(0.957)
Attended tertiary education	-0.187	-0.367	-0.215	-0.373	-1.168	-1.454	-1.209	-1.444
	(0.258)	(0.177)	(0.195)	(0.170)	(0.141)	(0.258)	(0.128)	(0.261)
Works full-time	-1.045***	-0.312	-1.057***	-0.318	-3.653***	-1.632	-3.651***	-1.627
	(0.000)	(0.111)	(0.000)	(0.105)	(0.000)	(0.079)	(0.000)	(0.080)
Practices sports	-0.723***	-0.491***	-0.722***	-0.490***	-6.054***	-4.863***	-6.046***	-4.864***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log rent	0.288	-0.0840	0.325*	-0.0361	1.761*	0.135	1.765*	0.111
	(0.068)	(0.712)	(0.041)	(0.875)	(0.019)	(0.900)	(0.020)	(0.918)
Log income	-0.537***	-0.433**	-0.542***	-0.436**	-3.323***	-2.912***	-3.313***	-2.901***
	(0.000)	(0.009)	(0.000)	(0.008)	(0.000)	(0.000)	(0.000)	(0.000)
BMI	0.123***	0.0254	0.124***	0.0256	0.531***	0.00694	0.535***	0.00861
	(0.000)	(0.461)	(0.000)	(0.457)	(0.000)	(0.966)	(0.000)	(0.958)
Number of persons in household	-0.0178	0.132	-0.0493	0.106	-0.111	0.454	-0.145	0.487
	(0.792)	(0.205)	(0.470)	(0.310)	(0.731)	(0.356)	(0.657)	(0.326)
Lives in Apartment	0.175	-0.295	0.131	-0.328	-0.719	-1.659	-0.786	-1.591
	(0.290)	(0.301)	(0.430)	(0.253)	(0.366)	(0.220)	(0.324)	(0.241)
Number of rooms	-0.134**	-0.144*	-0.111**	-0.125	-0.192	-0.233	-0.169	-0.257
	(0.001)	(0.025)	(0.009)	(0.055)	(0.337)	(0.444)	(0.404)	(0.402)
Noisy environment	0.143	0.00540	0.126	0.0100	1.572**	1.124	1.312*	1.012
	(0.202)	(0.967)	(0.276)	(0.940)	(0.003)	(0.072)	(0.017)	(0.111)
Vandalism environment	0.513***	0.170	0.506***	0.168	2.731***	1.768*	2.598***	1.717*
	(0.001)	(0.318)	(0.001)	(0.326)	(0.000)	(0.029)	(0.000)	(0.034)
_cons	4.286**	4.107	3.962**	3.640	23.70**	12.03	23.32**	11.99
	(0.005)	(0.080)	(0.010)	(0.122)	(0.001)	(0.278)	(0.001)	(0.282)
Observations	39769	39769	39769	39769	39769	39769	39769	39769
R-squared		0.00430		0.00448		0.00717		0.00720
P-values	1.57e-127	0	3.95e-126	0	9.08e-101	0	5.46e-100	0
Socio-economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed-effects	No	Yes	No	Yes	No	Yes	No	Yes

p-values in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix 3. Table 6 full version

	(1) Back problems	(2)	(3)	(4)	(5) Weakness	(6)	(7)	(8)	(9) Sleeping problems	(10)	(11)	(12)	(13) Headache	(14)	(15)	(16)
Poor housing conditions (1=yes)	0.00322	-0.00985			0.0224*	0.00501			0.0334**	0.0179			0.0208*	-0.00111		
	(0.764)	(0.413)			(0.039)	(0.687)			(0.001)	(0.121)			(0.038)	(0.922)		
Too small			0.0178*	0.0152			0.0236**	0.00562			0.0205**	0.0117			-0.00284	-0.00406
			(0.019)	(0.081)			(0.002)	(0.533)			(0.005)	(0.162)			(0.690)	(0.620)
Inadequate heating			0.00381	-0.00213			0.0123	-0.00622			0.0141	0.00332			0.0107	0.000527
			(0.624)	(0.804)			(0.121)	(0.483)			(0.058)	(0.687)			(0.140)	(0.948)
Poor air quality			0.0173*	0.0119			0.0214**	0.00485			0.0332***	0.0213*			0.0102	0.00915
			(0.030)	(0.192)			(0.008)	(0.606)			(0.000)	(0.015)			(0.175)	(0.284)
Gender	-0.106***	0	-0.105***	0	-0.156***	0	-0.155***	0	-0.0929***	0	-0.0925***	0	-0.157***	0	-0.157***	0
	(0.000)	(.)	(0.000)	(.)	(0.000)	(.)	(0.000)	(.)	(0.000)	(.)	(0.000)	(.)	(0.000)	(.)	(0.000)	(.)
Age	0.000349	0.00512***	0.000350	0.00516***	-0.00172***	0.00766***	-0.00173***	0.00767***	0.00167***	0.00559***	0.00165***	0.00570***	-0.00516***	-0.00428***	-0.00517***	-0.00428***
	(0.167)	(0.000)	(0.167)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Married	0.0106	0.0209	0.00996	0.0202	-0.0293***	-0.0177	-0.0302***	-0.0178	-0.00718	0.0151	-0.00813	0.0144	0.00238	-0.00882	0.00226	-0.00859
	(0.180)	(0.088)	(0.206)	(0.099)	(0.000)	(0.162)	(0.000)	(0.158)	(0.341)	(0.196)	(0.282)	(0.220)	(0.746)	(0.441)	(0.760)	(0.454)
Attended tertiary education	-0.0186*	0.00600	-0.0194*	0.00593	0.0186*	-0.00547	0.0175*	-0.00551	0.0233**	0.0210	0.0221**	0.0209	0.00604	0.0170	0.00594	0.0170
	(0.030)	(0.652)	(0.024)	(0.656)	(0.028)	(0.691)	(0.039)	(0.689)	(0.005)	(0.100)	(0.007)	(0.102)	(0.452)	(0.174)	(0.459)	(0.172)
Works full-time	0.00414	0.0107	0.00419	0.0106	0.00389	0.0230*	0.00374	0.0229*	-0.0267***	-0.00574	-0.0268***	-0.00597	0.00953	-0.000652	0.00950	-0.000646
	(0.557)	(0.266)	(0.553)	(0.269)	(0.580)	(0.021)	(0.594)	(0.021)	(0.000)	(0.534)	(0.000)	(0.518)	(0.149)	(0.942)	(0.150)	(0.943)
Practices sports	-0.0124*	0.00145	-0.0123*	0.00154	-0.0345***	-0.00784	-0.0345***	-0.00785	-0.0194***	-0.00844	-0.0192***	-0.00849	-0.000989	0.00569	-0.000961	0.00566
	(0.018)	(0.804)	(0.020)	(0.793)	(0.000)	(0.196)	(0.000)	(0.195)	(0.000)	(0.133)	(0.000)	(0.131)	(0.841)	(0.300)	(0.846)	(0.303)
Log rent	-0.0144	-0.0203	-0.0121	-0.0173	0.0159*	0.0250*	0.0183*	0.0254*	-0.0108	-0.0103	-0.00903	-0.00895	0.00598	-0.0141	0.00510	-0.0145
	(0.074)	(0.069)	(0.135)	(0.123)	(0.048)	(0.030)	(0.023)	(0.029)	(0.164)	(0.338)	(0.245)	(0.406)	(0.428)	(0.179)	(0.502)	(0.169)
Log income	-0.0146*	-0.00224	-0.0146*	-0.00224	-0.0252***	-0.00122	-0.0253***	-0.00125	-0.00584	0.00655	-0.00579	0.00663	-0.00256	0.0109	-0.00243	0.0110
	(0.021)	(0.783)	(0.021)	(0.783)	(0.000)	(0.884)	(0.000)	(0.882)	(0.334)	(0.400)	(0.339)	(0.395)	(0.664)	(0.152)	(0.681)	(0.148)
BMI	0.00735***	0.00819***	0.00740***	0.00826***	0.00123	-0.000190	0.00130	-0.000184	-0.0000135	0.000634	0.0000718	0.000663	0.00474***	0.00299	0.00476***	0.00299
	(0.000)	(0.000)	(0.000)	(0.000)	(0.148)	(0.913)	(0.126)	(0.916)	(0.987)	(0.696)	(0.932)	(0.683)	(0.000)	(0.060)	(0.000)	(0.059)
Number of persons in household	0.00406	0.000837	0.00263	-0.000411	0.00601	0.00335	0.00427	0.00280	-0.00900**	-0.0216***	-0.0106**	-0.0226***	-0.00211	-0.00255	-0.00185	-0.00230
	(0.242)	(0.870)	(0.454)	(0.936)	(0.081)	(0.524)	(0.220)	(0.599)	(0.007)	(0.000)	(0.002)	(0.000)	(0.517)	(0.594)	(0.575)	(0.634)
Lives in Apartment	-0.000469	-0.0134	-0.00213	-0.0149	0.00867	0.00110	0.00649	0.000134	-0.00460	-0.0262	-0.00688	-0.0275*	0.00741	-0.00265	0.00748	-0.00216
	(0.956)	(0.341)	(0.805)	(0.289)	(0.306)	(0.939)	(0.445)	(0.993)	(0.577)	(0.051)	(0.406)	(0.042)	(0.357)	(0.840)	(0.354)	(0.870)
Number of rooms	-0.00288	0.00223	-0.00209	0.00295	-0.00525*	-0.00124	-0.00422	-0.000993	0.00165	0.00731*	0.00260	0.00782*	-0.00330	0.00150	-0.00339	0.00131
	(0.182)	(0.480)	(0.338)	(0.353)	(0.014)	(0.704)	(0.051)	(0.762)	(0.424)	(0.016)	(0.214)	(0.010)	(0.102)	(0.612)	(0.097)	(0.662)
Noisy environment	0.0279***	0.0160*	0.0245***	0.0141*	0.0152**	-0.00864	0.0111	-0.00908	0.0415***	0.0204**	0.0360***	0.0178**	0.0175***	0.0115	0.0162**	0.0105
	(0.000)	(0.014)	(0.000)	(0.032)	(0.008)	(0.197)	(0.058)	(0.182)	(0.000)	(0.001)	(0.000)	(0.005)	(0.001)	(0.059)	(0.003)	(0.089)
Vandalism environment	0.0197**	0.00146	0.0178*	0.000291	0.0330***	0.0138	0.0308***	0.0135	0.0261***	0.0104	0.0231**	0.00908	0.00892	-0.000637	0.00830	-0.00107
	(0.008)	(0.862)	(0.018)	(0.972)	(0.000)	(0.112)	(0.000)	(0.119)	(0.000)	(0.196)	(0.001)	(0.259)	(0.203)	(0.935)	(0.238)	(0.892)
_cons	0.563***	0.206	0.543***	0.180	0.745***	-0.00858	0.723***	-0.0114	0.471***	0.133	0.452***	0.116	0.517***	0.455***	0.521***	0.456***
	(0.000)	(0.073)	(0.000)	(0.119)	(0.000)	(0.942)	(0.000)	(0.924)	(0.000)	(0.227)	(0.000)	(0.295)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	39769	39769	39769	39769	39769	39769	39769	39769	39769	39769	39769	39769	39769	39769	39769	39769
R-squared		0.00443		0.00457		0.00526		0.00529		0.00440		0.00459		0.00179		0.00184
P-values	1.19e-69	0	1.12e-70	0	2.57e-145	0	1.07e-147	0	2.56e-103	0	1.62e-106	0	1.16e-198	0	7.31e-197	0
Socio-economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed-effects	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

p-value in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix 4. Table 7 full version

	(1) Back problems	(2)	(3) Weakness	(4)	(5) Sleeping problems	(6)	(7) Headache	(8)
Poor housing conditions (1=yes)	-0.0110		0.00549		0.0118		-0.0267	
	(0.510)		(0.751)		(0.458)		(0.083)	
Too small								
		0.0161		0.0124		0.0147		-0.0180
		(0.214)		(0.356)		(0.236)		(0.133)
Inadequate heating								
		-0.0117		-0.00360		0.00909		0.0108
		(0.334)		(0.776)		(0.435)		(0.339)
Poor air quality								
		0.0124		0.00214		0.0209		0.0207
		(0.324)		(0.870)		(0.083)		(0.075)
Gender	0	0	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)	(.)	(.)
Age	0.00537***	0.00536***	0.00643***	0.00647***	0.00648***	0.00658***	-0.00591***	-0.00598***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Married	0.0388	0.0386	0.0212	0.0206	0.0292	0.0282	-0.0205	-0.0193
	(0.083)	(0.085)	(0.362)	(0.376)	(0.174)	(0.189)	(0.322)	(0.352)
Attended tertiary education	-0.0127	-0.0127	-0.0195	-0.0196	0.0189	0.0187	0.00308	0.00330
	(0.541)	(0.542)	(0.368)	(0.367)	(0.344)	(0.349)	(0.873)	(0.864)
Works full-time	0.0278	0.0276	0.0288	0.0289	0.00823	0.00823	-0.00976	-0.0102
	(0.073)	(0.075)	(0.073)	(0.073)	(0.579)	(0.579)	(0.496)	(0.479)
Practices sports	0.00991	0.00988	-0.0106	-0.0106	-0.00570	-0.00570	-0.00128	-0.00148
	(0.215)	(0.216)	(0.201)	(0.203)	(0.457)	(0.457)	(0.863)	(0.842)
Log rent	-0.0193	-0.0183	0.0278	0.0285	-0.0144	-0.0133	-0.00477	-0.00540
	(0.252)	(0.281)	(0.113)	(0.105)	(0.374)	(0.412)	(0.761)	(0.731)
Log income	-0.0196	-0.0196	0.00584	0.00583	0.00231	0.00253	0.0149	0.0151
	(0.102)	(0.102)	(0.639)	(0.639)	(0.841)	(0.826)	(0.180)	(0.174)
BMI	0.00624**	0.00634**	-0.000641	-0.000600	0.000183	0.000246	0.00198	0.00199
	(0.006)	(0.006)	(0.787)	(0.801)	(0.934)	(0.911)	(0.351)	(0.347)
Number of persons in household	0.00499	0.00362	0.0116	0.0105	-0.0281**	-0.0294***	0.0118	0.0133
	(0.588)	(0.696)	(0.226)	(0.274)	(0.001)	(0.001)	(0.168)	(0.122)
Lives in Apartment	-0.0122	-0.0142	0.0433	0.0421	-0.115*	-0.115*	-0.0645	-0.0623
	(0.832)	(0.806)	(0.470)	(0.483)	(0.038)	(0.037)	(0.229)	(0.245)
Number of rooms	0.00118	0.00149	-0.00909	-0.00891	0.0199**	0.0201**	-0.00176	-0.00192
	(0.874)	(0.842)	(0.241)	(0.251)	(0.005)	(0.005)	(0.799)	(0.781)
Noisy environment	0.0174	0.0163	-0.00143	-0.00159	0.0132	0.0109	0.0209*	0.0184*
	(0.065)	(0.086)	(0.883)	(0.872)	(0.142)	(0.229)	(0.016)	(0.036)
Vandalism environment	0.00247	0.00166	0.0210	0.0207	0.000546	-0.000440	-0.0120	-0.0127
	(0.821)	(0.879)	(0.065)	(0.068)	(0.958)	(0.967)	(0.237)	(0.209)
_cons	0.373*	0.364	-0.133	-0.139	0.200	0.183	0.482**	0.480**
	(0.044)	(0.050)	(0.491)	(0.472)	(0.260)	(0.306)	(0.005)	(0.005)
Observations	21321	21321	21321	21321	21321	21321	21321	21321
R-squared	0.00449	0.00469	0.00570	0.00575	0.00499	0.00529	0.00351	0.00371
P-values	0	0	0	0	0	0	3.02e-309	2.39e-291
Socio-economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dwelling fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

p-value in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix 5. Table 8 full version

	(1) Poor health status	(2)	(3) Health satisfaction	(4)	(5) Depression	(6)	(7) Number of doctor visits	(8)	(9) Number of Days affected	(10)
Poor housing conditions (1=yes)	0.0159		-0.0964		0.0733		0.136		-2.145	
	(0.249)		(0.094)		(0.271)		(0.726)		(0.222)	
Too small		0.00684		0.0299		0.0692		0.864**		-0.0353
		(0.522)		(0.505)		(0.182)		(0.004)		(0.979)
Inadequate heating		0.00989		0.0371		0.0281		0.201		-0.386
		(0.325)		(0.378)		(0.563)		(0.480)		(0.763)
Poor air quality		0.0199		-0.0222		0.0476		-0.117		0.113
		(0.056)		(0.611)		(0.345)		(0.691)		(0.932)
Gender	0 (.)	0 (.)	0 (.)	0 (.)	0 (.)	0 (.)	0 (.)	0 (.)	0 (.)	0 (.)
Age	0.00704***	0.00712***	-0.0604***	0.0605***	0.0155**	0.0159**	0.154***	0.157***	0.858***	0.853***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.005)	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)
Married	-0.00844	-0.00907	0.0476	0.0454	-0.0415	-0.0465	1.157*	1.098*	3.392	3.435
	(0.648)	(0.624)	(0.539)	(0.558)	(0.644)	(0.605)	(0.027)	(0.036)	(0.151)	(0.146)
Attended tertiary education	-0.0286	-0.0288	-0.0164	-0.0147	-0.0445	-0.0454	-0.817	-0.814	-2.789	-2.764
	(0.098)	(0.095)	(0.820)	(0.838)	(0.594)	(0.587)	(0.094)	(0.095)	(0.205)	(0.209)
Works full-time	-0.00920	-0.00915	0.0644	0.0637	-0.0463	-0.0458	-0.702	-0.699	-4.391**	-4.414**
	(0.472)	(0.474)	(0.230)	(0.235)	(0.455)	(0.460)	(0.052)	(0.053)	(0.007)	(0.007)
Practices sports	-0.0292***	-0.0292***	0.214***	0.213***	-0.0625	-0.0623	-0.378*	-0.376*	-5.287***	5.294***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.051)	(0.052)	(0.043)	(0.044)	(0.000)	(0.000)
Log rent	0.00976	0.0102	-0.0287	-0.0241	0.0651	0.0696	-0.0752	-0.0101	-0.356	-0.333
	(0.485)	(0.465)	(0.624)	(0.681)	(0.336)	(0.305)	(0.849)	(0.980)	(0.842)	(0.852)
Log income	0.000780	0.000980	0.0254	0.0260	-0.140**	-0.139**	-0.404	-0.400	-0.625	-0.626
	(0.937)	(0.921)	(0.541)	(0.531)	(0.004)	(0.004)	(0.149)	(0.153)	(0.621)	(0.620)
BMI	0.000491	0.000512	-0.0404***	0.0402***	-0.0265**	-0.0263**	0.00565	0.00855	-0.262	-0.257
	(0.795)	(0.786)	(0.000)	(0.000)	(0.004)	(0.004)	(0.916)	(0.873)	(0.277)	(0.286)
Number of persons in household	-0.00327	-0.00403	0.0262	0.0255	-0.0666	-0.0727	0.145	0.0822	-0.277	-0.260
	(0.667)	(0.599)	(0.412)	(0.428)	(0.071)	(0.050)	(0.500)	(0.704)	(0.775)	(0.790)
Lives in Apartment	0.0337	0.0335	0.161	0.165	0.130	0.126	0.994	0.962	-6.911	-6.901
	(0.480)	(0.482)	(0.423)	(0.411)	(0.575)	(0.586)	(0.462)	(0.476)	(0.257)	(0.258)
Number of rooms	0.000911	0.00102	0.0161	0.0171	0.0240	0.0250	-0.240	-0.225	-0.376	-0.369
	(0.882)	(0.869)	(0.532)	(0.509)	(0.423)	(0.403)	(0.169)	(0.197)	(0.632)	(0.639)
Noisy environment	0.0107	0.00864	0.00483	0.00391	0.0726	0.0672	0.138	0.133	1.524	1.499
	(0.167)	(0.270)	(0.882)	(0.905)	(0.054)	(0.077)	(0.530)	(0.549)	(0.124)	(0.134)
Vandalism environment	0.00783	0.00698	-0.0253	-0.0246	0.00171	0.000686	0.140	0.139	1.941	1.928
	(0.386)	(0.441)	(0.504)	(0.517)	(0.969)	(0.988)	(0.584)	(0.587)	(0.092)	(0.095)
_cons	-0.246	-0.258	11.26***	11.20***	3.233***	3.170***	0.877	0.161	-2.249	-2.399
	(0.108)	(0.093)	(0.000)	(0.000)	(0.000)	(0.000)	(0.840)	(0.970)	(0.908)	(0.903)
Observations	21321	21321	21321	21321	21321	21321	21321	21321	21321	21321
R-squared	0.00633	0.00657	0.0263	0.0262	0.00593	0.00605	0.00557	0.00613	0.00878	0.00869
P-value	0	0	0	0	0	0	0	0	0	0
Socio-economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dwelling fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

p-value in parentheses
* p < 0.05, ** p < 0.01, *** p < 0.001

Appendix 613. Table 9 full version

	(1) Poor health status (1=yes)	(2)	(3)	(4)	(5)	(6)	(7) Number of doctor visits	(8)	(9)	(10)	(11)	(12)
Poor housing conditions (1=yes)	0.000990	-0.0422	-0.0434				-0.188	-0.433	-2.021*			
	(0.967)	(0.208)	(0.479)				(0.677)	(0.532)	(0.030)			
Too small				0.0107	0.0406	0.0309				0.682*	0.815	1.547*
				(0.523)	(0.118)	(0.531)				(0.027)	(0.129)	(0.040)
Inadequate heating				0.00742	0.00467	0.0736				-0.155	-0.362	-1.093
				(0.722)	(0.874)	(0.124)				(0.697)	(0.550)	(0.132)
Poor air quality				0.00446	-0.0149	0.00702				0.000986	-0.577	-0.464
				(0.818)	(0.609)	(0.902)				(0.998)	(0.337)	(0.592)
Gender	-0.0346*	0	0	-0.0349*	0	0	-1.188***	0	0	-1.195***	0	0
	(0.017)	(.)	(.)	(0.017)	(.)	(.)	(0.000)	(.)	(.)	(0.000)	(.)	(.)
Age	0.0100	0.00814	-0.0180	0.0100	0.00800	-0.0183	-0.00277	0.0981	0.231	0.00644	0.104	0.295
	(0.061)	(0.271)	(0.277)	(0.060)	(0.279)	(0.273)	(0.979)	(0.521)	(0.359)	(0.952)	(0.496)	(0.245)
Sports	-0.0105	0.00263	0.0885*	-0.0107	0.00122	0.0890*	-0.181	-0.295	0.0879	-0.228	-0.326	0.146
	(0.494)	(0.899)	(0.027)	(0.488)	(0.953)	(0.026)	(0.543)	(0.491)	(0.884)	(0.444)	(0.447)	(0.809)
Log rent	0.0284	0.0739	0.0387	0.0303	0.0956	0.0999	0.204	-2.123	-3.504	0.311	-1.942	-2.358
	(0.222)	(0.307)	(0.749)	(0.195)	(0.186)	(0.416)	(0.615)	(0.156)	(0.057)	(0.447)	(0.194)	(0.206)
Log income	-0.00272	0.0259	0.106	-0.00272	0.0269	0.106	0.167	-0.188	-1.138	0.151	-0.174	-1.153
	(0.867)	(0.409)	(0.057)	(0.867)	(0.389)	(0.056)	(0.568)	(0.771)	(0.175)	(0.607)	(0.787)	(0.170)
BMI	0.00454*	-0.00416	0.00703	0.00460*	0.00404	0.00687	0.134***	0.0213	-0.147	0.137***	-0.0216	-0.129
	(0.048)	(0.380)	(0.430)	(0.046)	(0.396)	(0.445)	(0.001)	(0.828)	(0.276)	(0.001)	(0.826)	(0.343)
Number of person in household	-0.0104	0.000808	-0.0409	-0.0112	0.00463	-0.0425	-0.0436	0.539	0.573	-0.0969	0.417	0.578
	(0.153)	(0.978)	(0.393)	(0.130)	(0.873)	(0.376)	(0.724)	(0.363)	(0.430)	(0.441)	(0.485)	(0.427)
Apartment	-0.0461**	-0.201*	-0.236**	-0.0471**	-0.217**	-0.225*	0.570*	1.222	0.775	0.523	0.838	0.000260
	(0.006)	(0.015)	(0.009)	(0.006)	(0.009)	(0.015)	(0.046)	(0.473)	(0.570)	(0.068)	(0.624)	(1.000)
Number of rooms	-0.00641	0.00910	0.0165	-0.00580	0.0114	0.0191	-0.111	0.0408	0.133	-0.0723	0.0909	0.188
	(0.200)	(0.527)	(0.473)	(0.255)	(0.430)	(0.412)	(0.197)	(0.891)	(0.701)	(0.411)	(0.761)	(0.595)
Noisy environment	0.0384**	0.0493*	0.00918	0.0368*	0.0498*	0.0110	-0.109	0.0352	0.583	-0.136	0.000951	0.390
	(0.007)	(0.021)	(0.812)	(0.013)	(0.021)	(0.785)	(0.681)	(0.936)	(0.320)	(0.627)	(0.998)	(0.523)
Vandalism environment	-0.0295	-0.0682**	-0.0959	-0.0302	0.0700**	-0.0954	0.136	0.0305	-1.079	0.129	-0.0550	-1.165
	(0.109)	(0.010)	(0.091)	(0.102)	(0.008)	(0.092)	(0.695)	(0.955)	(0.209)	(0.713)	(0.920)	(0.175)
_cons	-0.183	-0.668	-1.059	-0.201	-0.832	-1.533	-3.703	15.62	37.98**	-4.530	14.55	28.30*
	(0.372)	(0.269)	(0.259)	(0.330)	(0.166)	(0.098)	(0.312)	(0.211)	(0.008)	(0.219)	(0.241)	(0.044)
Observations	1872	1872	467	1872	1872	467	1872	1872	467	1872	1872	467
R-squared		0.0377	0.130		0.0388	0.138		0.0185	0.125		0.0216	0.131
P-value	0.000348	5.94e-18	0.000189	0.000722	8.78e15	0.000324	0.0000745	0.995	0.000628	0.0000419	0.942	0.00156
Socio-economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Individual fixed-effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Dwelling fixed-effect	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes

p-value in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Appendix 7. Table 11 full version

	(1) Poor health status (1=yes)	(2)	(3)	(4)	(5)	(6)	(7) Number of days suffered	(8)	(9)	(10)	(11)	(12)
Poor housing conditions (1=yes)	0.000983	0.0203***	-0.00994				0.314	-0.104	-0.236			
	(0.18)	(3.29)	(-1.61)				(0.56)	(-0.16)	(-0.36)			
Too small				0.00305	0.000808	0.00105				1.003**	1.182*	1.058*
				(0.83)	(0.18)	(0.24)				(2.64)	(2.52)	(2.26)
Inadequate heating				-0.000210	-0.00196	-0.00300				-0.196	-0.685	-0.715
				(-0.04)	(-0.34)	(-0.53)				(-0.39)	(-1.14)	(-1.19)
Poor air quality				-0.00388	-0.00356	-0.00102				0.409	0.542	0.553
				(-0.79)	(-0.60)	(-0.18)				(0.81)	(0.88)	(0.90)
Age	0.00180***	0.000448	-0.0302	0.00182***	0.000551	-0.0275	0.00392	0.0226	-0.895	0.00398	0.0242	-0.154
	(4.08)	(-0.76)	(-0.15)	(4.11)	(-0.93)	(-0.14)	(0.09)	(0.37)	(-0.04)	(0.09)	(0.40)	(-0.01)
Gender	-0.0115*	0	0	-0.0116*	0	0	-0.616	0	0	-0.648	0	0
	(-2.35)	(.)	(.)	(-2.36)	(.)	(.)	(-1.32)	(.)	(.)	(-1.39)	(.)	(.)
Log rent	-0.00393	-0.00444	-0.00314	-0.00351	-0.00600	-0.00232	0.166	0.364	0.485	0.328	0.588	0.691
	(-0.72)	(-0.57)	(-0.41)	(-0.64)	(-0.76)	(-0.30)	(0.30)	(0.45)	(0.60)	(0.59)	(0.72)	(0.85)
Log income	-0.00237	-0.00393	0.00128	-0.00260	-0.00377	0.00101	-0.120	-0.576	-0.473	-0.205	-0.627	-0.524
	(-0.54)	(-0.63)	(0.21)	(-0.59)	(-0.61)	(0.17)	(-0.27)	(-0.90)	(-0.74)	(-0.46)	(-0.98)	(-0.81)
Number of persons in household	-0.00166	0.00288	-0.00241	-0.00195	0.00226	-0.00234	0.0610	0.714	0.714	-0.0306	0.579	0.595
	(-0.74)	(0.72)	(-0.62)	(-0.87)	(0.56)	(-0.60)	(0.28)	(1.73)	(1.73)	(-0.14)	(1.39)	(1.43)
Apartment	-0.00442	0.000347	0.000745	-0.00469	0.000218	-0.00126	-0.126	-0.553	-0.721	-0.233	-0.762	-0.911
	(-0.90)	(-0.04)	(-0.09)	(-0.95)	(-0.02)	(-0.15)	(-0.26)	(-0.61)	(-0.80)	(-0.48)	(-0.84)	(-1.01)
Number of rooms	0.000335	-0.00196	-0.00191	0.000592	-0.00200	-0.00175	-0.00540	-0.246	-0.312	0.0819	-0.134	-0.211
	(0.21)	(-0.80)	(-0.80)	(0.36)	(-0.80)	(-0.72)	(-0.03)	(-0.97)	(-1.23)	(0.50)	(-0.52)	(-0.82)
Noisy environment	0.00337	-0.00179	0.000342	0.00408	-0.00100	0.000418	0.736	0.543	0.486	0.613	0.433	0.379
	(0.91)	(-0.39)	(0.08)	(1.06)	(-0.21)	(0.09)	(1.94)	(1.15)	(1.03)	(1.55)	(0.90)	(0.79)
Vandalism environment	-0.00430	-0.00849	-0.00763	-0.00406	-0.00805	-0.00767	-0.0656	-0.282	-0.318	-0.106	-0.314	-0.348
	(-0.93)	(-1.54)	(-1.42)	(-0.88)	(-1.45)	(-1.43)	(-0.14)	(-0.49)	(-0.56)	(-0.22)	(-0.55)	(-0.61)
_cons	0.186***	0.104	0.106	0.186***	0.119	0.103	5.544	7.104	4.402	5.262	5.957	4.281
	(3.50)	(1.24)	(0.41)	(3.49)	(1.41)	(0.40)	(1.05)	(0.82)	(0.16)	(0.99)	(0.68)	(0.15)
Observations	12669	12669	12669	12669	12669	12669	12669	12669	12669	12669	12669	12669
R-squared		0.00634	0.000655		0.00710	0.00155		0.0666	0.00184		0.0664	0.000719
P-value	0.000145	4.52e204	1	0.0000352	2.70e225	2.29e-22	9.88e145	0	2.04e122	1.44e143	0	1
Socio-economic controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
Individual fixed-effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 12. Means of control variables

	Mean
Socio-economic characteristics	
Gender (1=male)	0.434
Age of respondent	46.14
Married (1=yes)	0.409
Attended tertiary education (1=yes)	0.199
Works full-time(1=yes)	0.383
Log income	11.33
Behavioural characteristics	
Practices sports (1=yes)	0.654
BMI	24.36
External Environmental characteristics	
Noisy environment (1=yes)	0.282
Vandalism environment (1=yes)	0.126

Table 13. Means of various health measures in relation with housing condition

Health measures	**Poor housing conditions**	**Good housing conditions**
	Mean	Mean
Self-assessed health		
Health status (1-5, 5=very well)	3.91	4.04
Poor health status (1=yes)	0.24	0.16
Health satisfaction (1-10)	7.52	7.84
Specific health problems (1=yes)		
Back problems	0.46	0.45
Weakness	0.48	0.45
Sleeping problems	0.36	0.34
Headache	0.37	0.33
Chronic illness	0.31	0.28
Depression (1-10, 10=always)	2.58	2.15
Objective health measures		
Number of doctor visits	5	3.5
Number of days affected	16.6	10.9

Statement of Originality

By signing this statement, I hereby acknowledge the submitted ~~paper/report/~~thesis*, titled: "The health effects of indoor housing conditions - *an empirical study"* to be produced independently by me, without external help.

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Date: *January 23rd, 2019*

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Course/skill: *Master Thesis*

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