The effect of owner-occupied housing conditions on health

"Decreasing Dutch healthcare costs through housing renovation"

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Executive summary

Dutch healthcare costs are among the highest in the world and this especially exerts pressure on the less wealthy share of the population. In this thesis will be determined that healthcare costs are partly driven by poor housing conditions of owner-occupied homes. The focus lies on this part of the population due to the fact that the majority of Dutch houses is owner-occupied (56 percent) and owners are expected to be able to control and adapt their indoor environment more easily than tenants. A panel data analysis making use of the LISS dataset has been executed with data ranging from 2007 to 2017.

We have found that housing conditions indeed have an effect on the health status of residents through different channels. A lack of light, for instance, leads to significantly less happiness resulting in more psychological healthcare visits. Hazardous problems, like leakages, damp and rot seem to negatively impact health in general which brings along both economic costs, through increased work hindrance, and higher healthcare costs resulting from an increased amount of visits to healthcare facilities. After controlling for socio-economic effects and demographics we found that, on the one hand, both males and females seem to be sensitive to a lack of light. On the other hand, it appears that men are more susceptible for inadequate heating and leaks while women suffer more when experiencing damp or rotten surfaces. Moreover, there is partial evidence that older people's health is impacted more seriously by housing problems.

One of the main lessons from this thesis is that it would be beneficial to renovate certain housing types with innovative and sustainable solutions not only for an increase in WOZ-value but for health reasons as well. With the aid of a stakeholder analysis, we have been able to provide suggestions for a change in both the business models of involved stakeholders and the eco-system around the field of interest. A proposed solution entails that housing developers should cooperate with health insurers, for example through discounts for healthy homes, as an incentive for healthier building and renovation practices. As a result, this will enable home-owners to take control of poorly maintained housing more easily. The government's role should be to support this mechanism in any way possible and the introduction of a "Health-Index", as a complement to existing energy-indices, could prove to be valuable.

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1. Introduction

Since 1982, the Dutch Ministry for Public Health, Well-being and Sport (VWS) has been striving for noble objectives involving the quality and affordability of healthcare for all residents of the Netherlands. Both physical and mental well-being are among the most important rights a human being has. Therefore, it is not surprising that this topic has been highly prioritized on the political agenda for the last decades. How high should the healthcare costs for own account be? Should we even have these costs? How do we make sure every citizen can afford healthcare while still ensuring a high quality? While all being relevant questions, it has proven to be difficult to answer them. Compared to other Western countries, Dutch healthcare costs are among the highest together with Sweden's, Denmark's and Germany's with an approximate 10 percent of GDP (World Data Bank, 2014). Figure 1 provides an overview of healthcare costs in the rest of Europe.

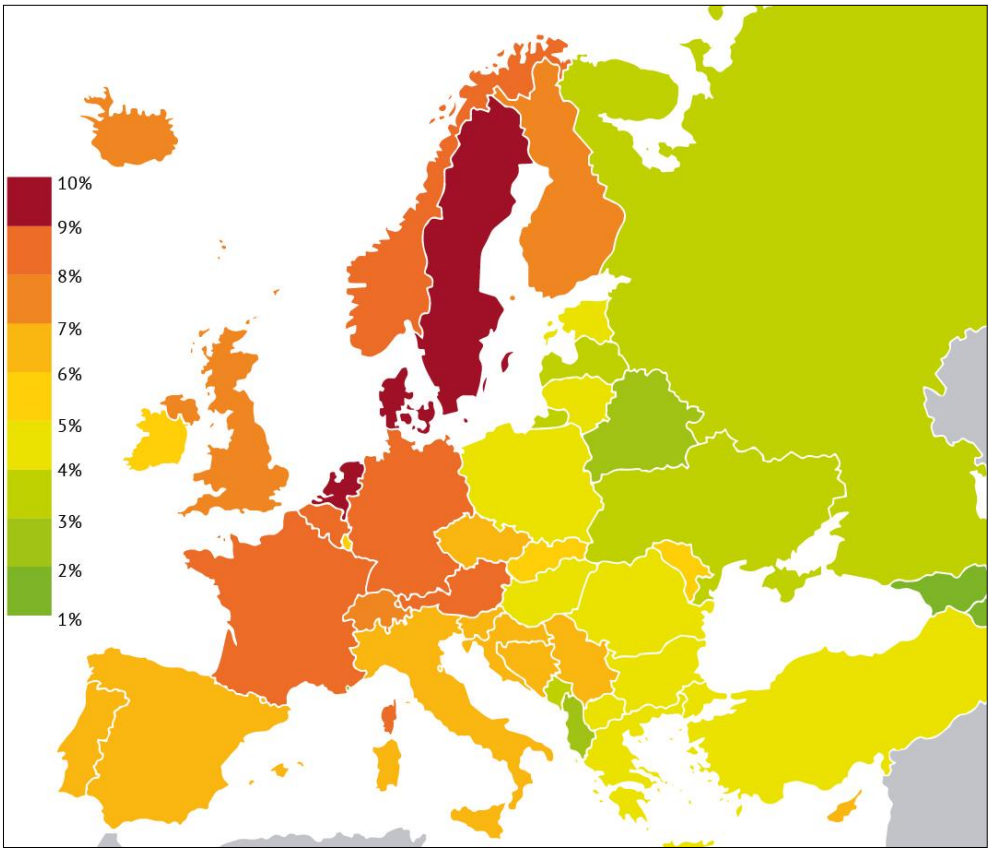

Figure 1: European healthcare costs as a percentage of GDP (World Data Bank, 2014)

On the one hand, this has ensured a sustainable top-tier quality of healthcare in the Netherlands with a first place on the most recent Euro Health Consumer Index (EHCI) (Björnberg, 2017).

However, on the other hand, the affordability has been under pressure especially for the relatively poor share of the population. A first step in improving the affordability of health care, might be to look at its causes. The link between outdoor conditions and health has already been researched extensively but an upcoming and relatively untouched perspective involves the effect of the indoor quality on health. Particularly, housing conditions might play an important role because these conditions are the ones to which the degree of exposure is the highest for most people. Is there a link between housing conditions and health? If yes, could an improvement of housing conditions result in lower healthcare costs?

1.1. Business motivation

My main intrinsic motivation for choosing a topic involving the effect of housing conditions on health is the degree of societal impact the findings could have. Finance Ideas B.V., the company which supported me during my TIP, perfectly sketches why this could be the case. Finance Ideas is active in three seemingly separate fields being (1) healthcare instances, (2) social housing associations and (3) institutional investors. Some of their main practices involve consultancy for institutional investors' real-estate portfolios, aid with the implementation of housing regulations and general assessment of the financial continuity for healthcare instances. In line with governmental conclusions, Finance Ideas points out that the individual's ability to afford healthcare has since recently been under pressure due to drastically rising healthcare costs. Measures to increase personal healthcare costs are therefore more crucial than ever nowadays. Accordingly, it would be interesting to examine whether poorly maintained houses truly decrease the overall health level of the inhabitants and thereby drive healthcare demand and its costs. Until now, companies with an advisory role for real estate have been advocates of sustainability, which in essence is a good development. However, simultaneously these advisors have noticed the rising healthcare costs while not explicitly realizing a relationship between housing and health. Dependent of the results of this thesis, companies like Finance Ideas could shift their aim towards a revised advisory role with regards to housing quality beyond plain sustainability and energy labels. In addition, housing developers might have to adjust their strategy towards their properties and possibly work together with insurers to accomplish a successful shift to healthier homes.

1.2. Academic motivation

Several different strands of literature have already sketched a direct relationship between people's environment and their health. First of all, a significant link between an individual's income and their health status has already been established in a substantial amount of research done in the US, UK and Germany (Adams, Hurd, McFadden, Merrill & Ribeiro, 2003; Contoyannis, Jones & Rice, 2004; Frijters, Haisken-DeNew & Shields, 2005).

Another popular strand of existing literature has proven numerous times that there is a causal effect of outdoor conditions on human health. For example, Deschênes and Greenstone (2011) added to the growing evidence by discovering negative causal relationships between environmental hazards, such as extreme temperatures and accompanying droughts and floods, and human health. In addition, a similar link for air pollution was found. As aforementioned, however, this research relies on data on outdoor conditions leaving a gap which this thesis will attempt to fill. Especially for Western countries, where 90 percent of a person's day is spent indoors (Klepeis et al., 2001), this could be a more appropriate proxy for conditions affecting people's health. Of all the time spent indoors, the majority passes in and around the house, for instance approximately eight hours are spent in bed, amplifying the importance of revealing a relationship between housing conditions and health.

The last strand of literature suggests that there is a positive relationship between indoor conditions as a result of policy changes and health with the example of a study conducted by Cattaneo, Galiani, Gertler, Martinez and Titiunik (2009). This paper suggests that, after policy interventions by the government in poor regions of Mexico, dirt floors had to be replaced with cement floors which in turn resulted in less allergies and respiratory issues. Even though this somewhat displays the effect this thesis wants to capture, a research gap remains whether this result can still be observed in developed countries like the Netherlands where housing conditions are already quite satisfactory.

1.3. Problem statement

The central problem statement for this research study will be:

"What is the effect of owner-occupied housing conditions on health?"

Within this general problem statement the focus will lie on whether poorly-maintained houses report a higher number of bad health cases. Since the independent variable as well as the

dependent variable can be regarded as subjective, it is of importance to make use of proxies that are as suitable as possible for both housing conditions and health status.

As aforementioned, the approach used in this thesis could establish a causal relationship between housing conditions and human health in a more reliable manner than existing cross sectional surveys. Therefore, the results could possibly to a large extent be generalized to other Western countries. One of the major implications this study could bring forward is whether improved housing conditions can contribute to a reduction in health expenses on an individual level. This would in turn be an indication of the benefit of housing renovation from a different perspective than usual. An indirect implication could be that gathered evidence points towards a sustainable way of construction with measures such as better isolation, heat pumps and more sustainable materials in general. This would require housing developers to change their strategy towards building and renovation.

The remainder of this thesis will firstly elaborate on the existing literature with a review in section 2. This section will then be concluded and sub questions will be formed. In section 3, the research design will be discussed by providing a thorough explanation of the LISS dataset and the empirical strategy used to establish reliable results. These results will, consequently, be presented in section 4. Furthermore, a subjective interpretation of the results will be discussed in section 5. Lastly, the thesis will conclude and glimpse at some limitations and implications for further research.

2. Literature review

Over the last decades, a considerable amount of research has been conducted on various fields revolving around housing conditions and health. In the upcoming sections the existing literature will be reviewed and interpreted in a coherent manner in order for us to retrieve more information on how past research translates different concepts into variables and what previous findings could predict for this thesis. The literature review will be approaching the topic from a conceptual perspective from which the involved factors will be identified and elaborated on. First of all, the concept of health will be placed in an academic perspective. After that, we will increase our in-depth knowledge of the indoor environment followed by an examination of the outdoor environment which will be used as a degree of control later on. Finally, several remaining topics will be discussed mainly focusing on demographics. Progressing through the

literature review, we will use data and literature focusing solely on the Netherlands to sketch the current situation of the country the LISS dataset originates from.

2.1. Health

Health has already been a research topic of interest since the time of Hippocrates in 460 B.C. and has been fuelled by researchers with an ever-growing source of literature. This section will examine different measures of health as they have been used in other articles in order to get an impression of the research field which will enable us to decide on appropriate measures to use for this thesis. In 1972, Michael Grossman was one of the first to consider "good health" as a commodity. With his "Health Capital Theory" he proposed that each individual inherits a certain "stock" of health which depreciates over time as age increases. However, just as in the financial sector one can "invest'' in this good by undertaking healthy activities like sports, for example, and "divest" by performing unhealthy activities such as smoking and drinking. Grossman's theory has been a foundation for different types of research on, for instance, how the depreciation of health can be derived and what the determinants of health investment demand are. An individual's health status can be measured in numerous ways but in general a few major methods of measurement can be distinguished. First of all, a series of common measurements for health status can be observed in the literature. Besides, health can be proxied by examining the degree of activity hindrance from health issues. Lastly, a proven method for measuring health is an examination of the demand for healthcare facilities.

2.1.1. Health status

Measurements for health are often highly subjective to the age group on which a certain strand of literature focuses. An example is the evidence that air pollution reductions in California in the 1990s prevented approximately 1,000 children from dying (Currie & Neidell, 2005). Besides infant mortality rates, a well-known approach for testing child health is the registration of birth weights (Currie, Davis, Greenstone, & Walker, 2015) with the underlying reasoning that low birth weights could portray an unhealthy environment.

With regards to research on elderly health, one often makes use of health problems that are specific for this age group. Ferreira et al. (2009), for instance, managed to find a relationship between Alzheimer occurrence and the concentration of aluminium and other metals in drinking water in retirement homes. Moreover, just as for the younger age group, mortality rates are

often a highly appropriate indicator for elderly health. It makes intuitive sense that both children and the elderly are in some cases more sensitive to specific types of exposure, but more on this in a later section.

Another common way of measuring health is the conduction of surveys asking for an individual's personal perception of their health. Many questionnaires in the field of interest contain questions like "how healthy do you feel?" or "can you rate your health?" for which the respondents can indicate their answer on a Likert scale (Malmström, Sundquist & Johansson, 1999; Pampalon, Duncan, Subramanian, Jones, 1999; Eigenbrodt et al., 2006). These surveys can be used for examining both mental and physical health status as well as a combination of the two.

2.1.2. Health hindrance

In addition to the previously described common indicators of human health, it is of importance to consider that health problems are accompanied by foregone profits. In other words, being sick carries a certain opportunity cost for not being able to do something you would have done in case you would not have been ill. This opportunity cost of health problems will be described as "hindrance" from now onwards in this thesis.

For the largest group of society, hindrance plays an important role for their employment. An article by Hanna and Oliva (2015), aimed at estimating the effect of the closure of an oil refinery in Mexico City and reported that this shutdown resulted in a 19.7 percent decline in SO_2 pollution. More interesting is the fact that this decrease in pollution lead to a significant increase of 1.3 working hours per person per week in the area which was equivalent to a 3.5 percent increase of labor supply. At first sight this might not look like a significant change, but taking into account the fact that "human resources" boils down to the biggest cost driver of many companies sheds a different light on the situation. These costs include salary, employment costs such as training, and general occupation costs. According to David Clark (2013), employee costs make up around 89 percent of total operating costs (figure 2) as described in his book "*What colour is your building?*". The figure, moreover, shows that energy consumption amounts to approximately 0.6 percent of all company costs. Therefore, it could be concluded that striving for productivity growth while increasing energy usage is justifiable, from a business perspective. All in all, the amount of sick leave is an extremely relevant measure of health especially in business terms.

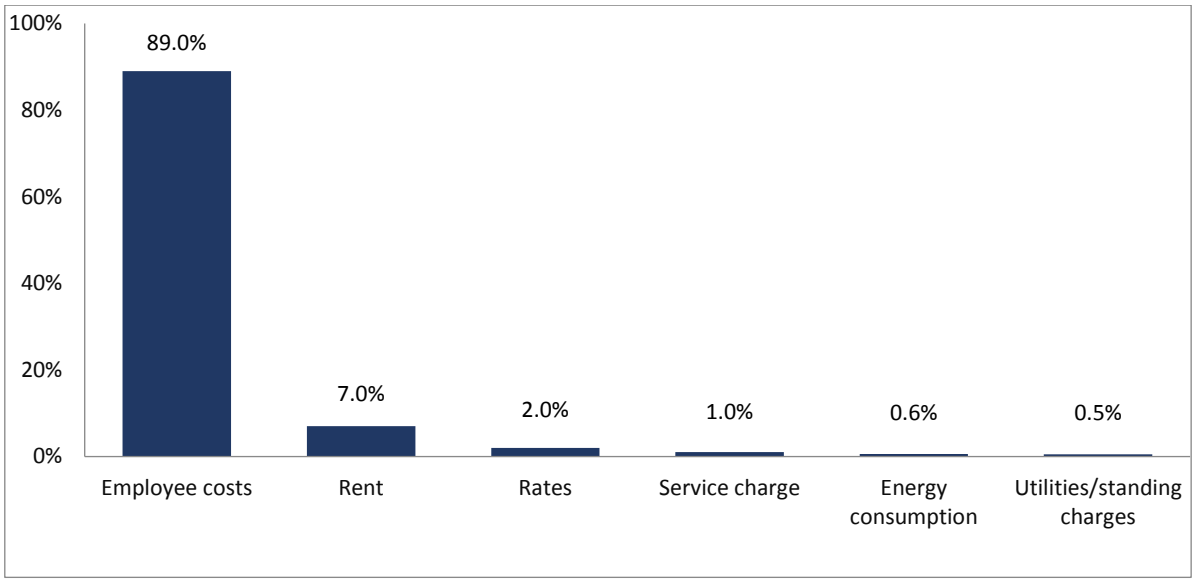

Figure 2: Proportion of annual costs per m^2 of Net Lettable Area (NLA): (Clark. D., 2013)

Besides work hindrance, another form of opportunity costs incurred by illness is the amount of school absences. Ransom and Pope (1992) gained similar results as aforementioned research in the sense that in an area with increasing pollution levels the degree of school absenteeism tends to increase hand in hand.

Needless to say is the fact that there is a high likelihood that school and work activities are not the only ones affected by health issues simply because they have been the most economically relevant for research objectives. One could imagine that illness also has a negative impact on social activities (Barf et al., 2009) which could in turn lead to a decrease of an individual's mental well-being, therefore being something that should not be neglected. Moreover, illness is highly likely to increase someone's dependency on others since the execution of daily tasks could be undermined (Hoare, 2008) ultimately decreasing the overall standard of living. Interesting are the findings by Bornstein (1995) stating that a high degree of dependency on others carries a higher risk of experiencing physical illness in the future, pointing in the direction of a self-fulfilling prophecy.

2.1.3. Healthcare usage

The last approach to human health measurement is based on an analysis of the usage of health care facilities. It is safe to assume that people who are unhealthy are in general more likely to go to a doctor than people who are perfectly healthy. An important issue with reference to this

assumption is the extent to which health care costs are affordable for unhealthy people. Nowadays, there are numerous different types of health care facilities ranging from doctors to dentists and from psychiastrists to paranormal healers. To some extent, health care facilities could be grouped into either physical healthcare or mental healthcare providers.

The World Health Organisation defines health not merely as the absence of disease and adverse physical effects, but also describes it as "a state of complete physical, mental and social well-being". Past research has already attempted to prove the impact of several variables on physical and mental health factors in order to conclude more specifically which type of health is affected by what factors. An example is the research done by Héritier et al. (2014) on whether noise, being either traffic, industry or neighbour-related, has an effect on the annoyance level of individuals. On the one hand, they measured the impact of the annoyance level on the Von Zerssen symptom list which entails 24 possible somatic complaints about someone's physical status and, on the other hand, on the SF-36 score for mental health. Moreover, they discovered BMI and sleep disturbance to be positively moderating variables for annoyance subsceptibility. Their article uncovered that different types of annoyance had varying degrees of impact on physical and mental health, hence amplifying the benefit of this distinction in healthcare usage.

In line with Schlenker and Walker (2016) it is also common to use the costs of healthcare as a proxy for health. Increasing costs would partly be a direct result from increased usage of healthcare by, for example, more visits to a healthcare facility in a year. Following this line of reasoning they were able to establish a positive relationship between the proximity to an airport, and therefore exposure to its CO_2 emission, and healthcare costs.

The division of Dutch healthcare costs is presented in figure 3. It becomes clear that healthcare laws are the main sources of healthcare funding. These healthcare laws are backed by health insurers who receive monthly payments from Dutch citizens. Additionally, the government and personal risk regulations pay for a substantial share of the total healthcare bill.

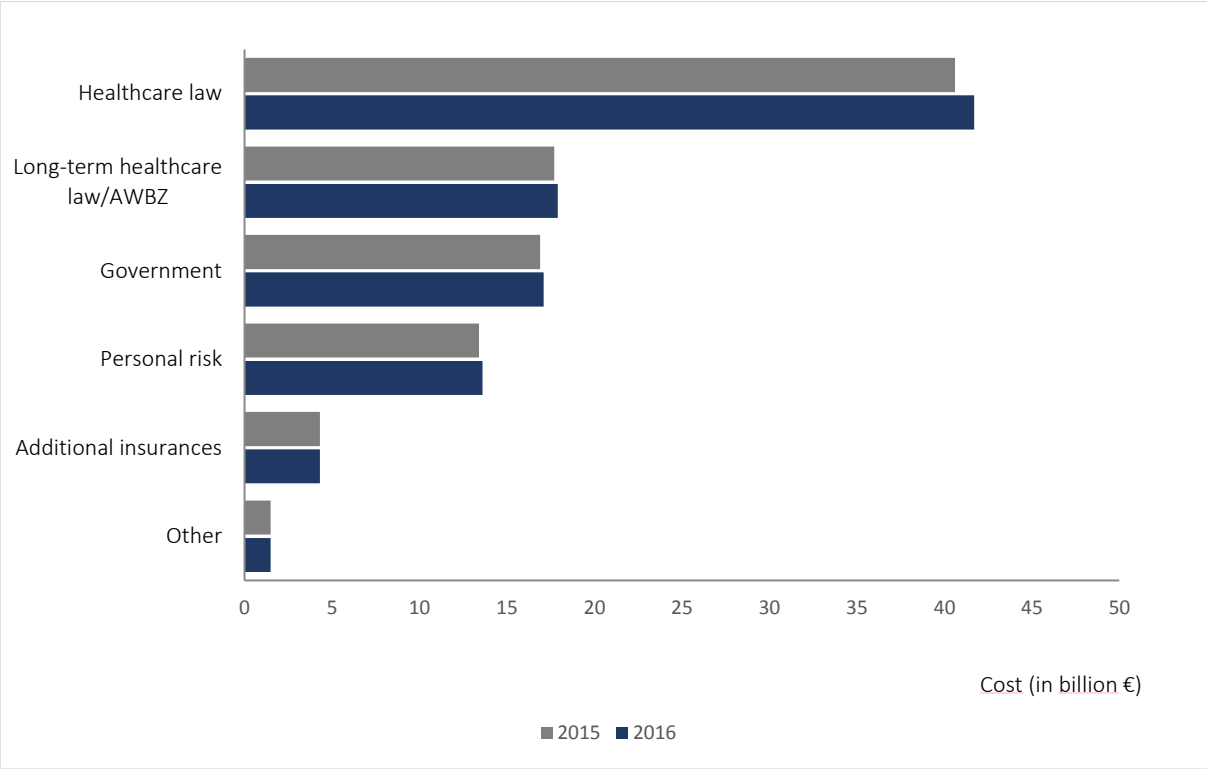

Figure 3: The division of Dutch healthcare costs (CBS)

All in all, the existing literature on health is extensive and provides us with sufficient suggestions and approaches towards covering the topics of (1) health status, (2) health hindrance and (3) healthcare usage.

2.2. Housing conditions

When thinking about housing conditions and quality, often times the words "sustainability" and "energy label" come to mind. Needless to say, these are definitely terms that characterize housing quality but whether sustainable houses are also more healthy could be questioned. Ajayi, Oyedele, Jaiyeoba, Kadiri and David (2016) claim that sustainable buildings have a lower negative impact on human health than their unsustainable counterparts. They substantiate this by directly linking a building's "global warming potential" (GWP) to human health whilst portraying a negative relationship. The contrary perspective claims that some sustainable systems are not healthy at all. Nowadays, it is preferred that buildings are as isolated as possible in order to save on the energy bill. However, by doing this the ventilation could be hampered and air contamination from inside might occur as a result of air not getting refreshed sufficiently often. The Institute of Medicine hits the nail on the head by stating that "sharp distinctions

between health and comfort are not always readily apparent and may not be appropriate" (Ted Schettler, 2007). This section will describe a collection of literature revolving around indoor housing conditions in an attempt to grasp the essence of this research field.

According to Brounen, Kok and Quigley (2012), gas and electricity usage is to a certain degree dependent of both housing conditions and resident characteristics. Their main findings were that gas consumption is principally determined by housing conditions such as building type, building year and other factors such as heating and insulation. Contrarily, electricity usage tends to vary more with resident characteristics such as income and family composition. These findings augment the necessary awareness that demographics can have a mediating effect on the impact of housing conditions. This will be further investigated in the demographics section.

Concerning the effect of housing conditions on health, an exploratory report has been written based on an experiment in Sweden. Engvall et al. (2010) designed a "Sick Building Symptoms" (SBS) model in which their objective was to determine the characteristics of residents reporting "Sick Building Syndrome", a term invented by the World Health Organization (WHO) in 1986. The symptoms include eye, nose, cough, throat and facial skin problems unrelated to a resident's chronic issues. Ownership and socio-economic factors have proven to be relevant influencers of the number of SBS observations. Moreover, a positive relation between rented housing and SBS cases was found indicating a higher probability of "risk buildings" among rental properties. A similar approach is taken with the "Building Symptom Index" (BSI) in which the mean number of symptoms reported by occupants is calculated in an attempt to score how healthy a building is (Bluyssen, 2009).

Another proxy for housing conditions in the current literature is a self-assumed measure of how people judge their own housing quality such as in the German SOEP survey used by Aydin, Eichholtz, Kok and Palacios (2017). In their research on this dataset a distinction between three housing condition scenario's was made being (1) in good condition, (2) in need for minor renovation and (3) in need for major renovation. The writers managed to find evidence for a positive relationship between the need for renovation and the usage of healthcare facilities. Moreover, there is evidence that the effect is stronger for women and people above 50 years old.

Even though the aforementioned measures are good indicators of housing conditions, it is more credible to signal a building's health status with a certificate of some kind. This concept has been picked up in the United States with the introduction of the WELL certificate in 2013 by

the International WELL Building Institute (IWBI). This certificate distinguishes healthy (office) buildings around the world by assessing the satisfaction of the following features: air, water, nourishment, light, fitness, comfort and mind. Light, for example, represents a housing characteristic that could enhance its residents' health level. Tisdall (1926) was one of the first to draw a link between the amount of sunlight and human health mainly due to its provision of Vitamin D. A dwelling that does not allow for sufficient lighting could be subjective to a lack of this essential vitamin. Another expected key indicator is air quality with the WHO (2014) claiming that every year an estimated amount of 200,000 Americans face premature death due to poor air quality. This number is estimated to lie between seven and eight million globally. This in combination with the knowledge that indoor air quality is considered to be two to five times as polluted as outdoor air quality (United States Environmental Protection Agency [EPA], 2017) should convey the message of the urgency of improving interior air conditions. Underlying each WELL feature is a checklist amounting to a total score on which the granting of the certificate depends.

According to the IWBI, the WELL standards should be used as a complement to already existing sustainability standards such as LEED, BREEAM and Green Star. Their coexistence immediately uncovers a very important concern about the attempt of making a building healthier. If the focus lies too heavily on creating a healthy indoor environment the risk is that this might affect the external environment. For instance, offering better air quality through innovative ventilation and purification systems could enhance the productivity of the people within a confined space as proven by Silva et al. (2017) in their experiment in different class rooms with different air qualities. However, these measures could go hand in hand with an increased consumption of electricity and therefore more greenhouse gas emissions. This mechanism is relatively similar to the aforementioned negative relationship between isolation and ventilation further strengthening the difference between sustainable and healthy buildings. However, Fisk, Black and Brunner (2012) claim that any extra energy costs are far exceeded by the benefits in terms of productivity, cost savings and health. A more subtle approach that could be taken involves passive measures to reduce air pollutants, such as green walls. Green walls are a form of sophisticatedly allocated vegetations, such as plants and small trees, in buildings to provide a higher oxygen level. Cundall, the first company whose office in Europe received the WELL certificate, installed such green walls. Another initiative with the name "Health Optimisation Protocol for Energy-efficient Buildings" (HOPE) was already successful at pointing out that buildings could be made energy efficient and healthy at the same time by

ensuring a decrease of energy use while simultaneously decreasing CO_2 emissions from heating and ventilation. Recently, more programs incorporating both health and sustainability have been initiated in Europe such as the Healthy Buildings conference in which guidelines and policies are discussed while taking into account the health effect of buildings.

2.2.1. Housing conditions in the Netherlands

Enriched with the knowledge of which variables and conditions are considered to be of importance for a healthy indoor environment, the possibility of examining the current state of the Dutch housing market arises. This section will investigate which possibly problematic housing conditions are the most apparent in the Netherlands and back this up with literature focusing on Western Europe.

According to the Dutch Institute of Public Health and Environment (RIVM), the majority of all houses has an indoor quality problem to at least some extent. A collection of the most currently available data will be discussed in this paragraph. Note that this data is not as recent as would be preferred so percentages might be slightly lower in reality, however, the problems are not easily solvable in the short term so they will represent a realistic view explaining why the RIVM still values them. Firstly, it is evident that a majority of Dutch houses contains Radon (Gastra, Hiemstra, De Vries, Lembrechts and Stoop, 1998). Radon is an odorless and colorless radioactive gas produced by the decayment of uranium. It is present in almost all types of soil and people breathe in small proportions of it on a daily basis. Long-term exposure could cause lung cancer and the danger arises if radon gets trapped in houses through gaps and cracks in the concrete. A direct link can therefore already be drawn between the quality of building surfaces (e.g. walls and floors) and health. Moreover, even though the percentage is decreasing, some houses still contain asbestos and house dust mite (Jongeneel, Van Balen, Koudijs, Staatsen and Houweling, 2009) which could cause health problems for the residents as well. In addition, around 12 percent of the dwellings still makes use of flueless systems for warm water and heating allowing for the emission of hazardous CO and NO_2 (Van Egmond, Gopal and Poulus, 2007). Furthermore, according to Van Dongen and Vos (2007), 9 percent of the houses has visible, and therefore seriously dangerous, occurrences of mold. Needless to say is the fact that these issues all have their impact on health but more striking is the conclusion that, despite the decreasing existence of these problems, sustainable building has not yet been able to totally erode them. In some situations sustainable building has even lead to counterproductive results

as discussed in a previous section. For instance, air conditions are a major determinant of indoor quality and, with the modern well-isolated housing trend, residents feel more obliged to manually ventilate by opening a window, for example, which oftentimes does not suffice towards meeting the standards for air quality (Jongeneel, Bogers and Van Kamp, 2011; Van Dijken and Boersma, 2011).

As a result of mentioned research and stimulation by several ministries, the National Approach for Environment & Health (NAMG) decided to shift their focus more heavily to indoor climate quality in the period 2008-2012. A report in 2014 by the RIVM looked back at this 4-year time period and concluded that awareness had increased indeed while several valuable quality labels and regulations for healthy indoor climate and building materials, such as the KOMO label and anti-smoking regulations, have been successfully implemented. Despite clear improvements, the report also stated that, since after the NAMG period, no stakeholder has been taking responsibility for these issues anymore (Staatsen et al., 2014). This is an indication of the fact that new measures and continuing discussion are still extremely necessary.

Overall, previous literature has already successfully drawn some links between building conditions and their effect on human health but fails providing the same proof for housing. Based on this collection of findings we can already get an indication of the outcome of the problem statement and more specifically the subquestions that will be presented later on. It is crucial to prevent underestimation of housing problems in the Netherlands as the RIVM suggests. Interesting would be to find out which housing conditions lead to which health effects and to what degree in order to enable people to prioritize when it comes to renovations. Notwithstanding, to what extent does the external environment play a role in this relationship?

2.3. External environmental theory

In order to isolate the effect of housing conditions on health it is of importance to consider a substantial amount of other factors. Does the relationship differ in varying neighbourhoods? Are specific age groups more sensitive to housing conditions or does gender matter more? Do people try to fix their housing problems or rather move and does this differ between rental and owner-occupied houses? All these types of questions should be taken into account when identifying the true relationship between housing conditions and health. This section will provide an overview of past research with regards to external conditions surrounding the central

field of interest. These conditions should be contemplated in order to reduce the level of noise within this thesis.

2.3.1. Air Quality

One of the most obvious aspects of the external environment is the vicinity to factories and traffic instigating the exposure to stench, noise and poor air quality. Whether a dwelling is situated in an urban or a rural area plays a key role here. Aforementioned articles on the health costs of pollution perfectly explain the conspicuous effects of this exposure on human health. With the recognition that air quality can indeed have detrimental effects on health we can examine what the situation in the Netherlands looks like. According to the RIVM, the concentration of particulate matter ($PM_{2,5}$) lies above the MAC-value in 13 out of 390 municipalities. This number has been highly volatile over the years since a fair share of municipalities operate just below the maximum. Especially busy cities near highways have difficulties decreasing the ppm-level of $PM_{2,5}$ (Van Zanten et al., 2016). Exposure to air pollution accounts for approximately three to five percent of total healthcare costs in the Netherlands (Hänninen and Knol, 2011) and could thereby be considered an equally serious issue as obese (5%) and more influential than alcohol abuse (3%) and eating too little fruit and vegetables (2%).

2.3.2. Noise

Another hot topic on external environmental effects involves noise levels. Since the 1980s there has already been evidence on a higher occurrence of psychiatric diseases among people who claim to be annoyed by neighbourhood noise. However, it is hard to distinguish causality from correlation since this relation could also stem from the fact that people with psychiatric diseases are more sensitive to neighbourhood noise. Nevertheless, it is apparent that noise could be a tremendous problem and therefore several regulations with reference to European insulation requirements have been in place. These rules should ensure that unwanted sound is absent and regular sounds should have the right level and quality while normal activities can be done without being heard by other people to an annoying extent. Despite this, Rasmussen (2010), argues that these regulations are not strict enough among European countries while simultaneously lacking uniformity. This statement has been supported by recent academic work as well. According to Weinhold (2016), disproportionally high noise levels have a significant

positive effect on health costs. One could argue that traffic and industry noise effects on health are highly correlated with the air quality around these areas. However, further research has proven that, despite this correlation, neighbourhood noise carries a causal relationship with health and more specifically increased sleep disturbance. In turn, this could lead to increased occurrences of cardio-vascular symptoms, joint and bone disease and headache.

As previously mentioned, it has been proven that noise can have a negative effect on both physical and mental health (Héritier et al., 2014). Therefore, regulations aimed at protecting the society are definitely essential. The situation in the Netherlands is, unfortunately, far from perfect. As table 1 portrays, traffic noise is considered to be the second biggest driver of our healthcare costs, after $PM_{2,5}$, measured in disability adjusted life years (DALY) (Hänninen and Knol, 2011). Especially in large cities in the "Randstad" the prevalence of traffic noise is in some cases far from desirable.

Environment factor	Healthcare cost in DALY's
Particulate Matter ($PM_{2,5}$)	135500
Traffic Noise	12615
Tobacco fumes in surroundings	12201
Radon	7374
Dioxins	3936
Pb_2	3535
Ozone	547
Benzene	26

Table 1: Key environmental factors and their healthcare costs in DALY's (Hänninen and Knol, 2011)

2.3.3. Additional external conditions: Water and radioactive exposure

Besides research-intensive topics such as air quality and noise problematics, the RIVM discusses other issues affecting human health where improved housing quality could offer a solution, at least to some extent. Firstly, the quality of everyday used drinking water has to be on point concluding from examples of massive illness and death amounts in the poorer regions of the world as a result of bad drinking water. The Inspection on Living environment and Transport (ILT, 2016), however, claims that only 0.07 percent of Dutch drinking water contains an above maximum level of possibly damaging material, which is a negligible concern.

Another topic the RIVM deems important is the amount of exposure to radiation. They distinguish between three main types of exposure: Ionizing-, UV- and Electromagnetic radiation. The level of ionizing radiation has been increasing exponentially in the last decades as a direct result of technological advance, for instance Röntgen photography, and increased use of nuclear material. The measures that can be taken by housing associations against ionized

radiation are marginal. However, Radon is also considered to be ionized radiation and the Dutch trend towards Radon neutral houses has been a successful one since 2000. In houses built after 2000 the average concentration of radon is 22 percent lower than the average of the 70 years before, thereby achieving agreements made between the government and building companies for new housing (Smetsers, Blaauboer, Dekkers, Van der Schaaf and Slaper, 2015). Next, even though UV radiation could have serious health consequences, it is not a health factor taken into consideration when building a house since it only affects people directly in contact with the sun. At most, housing developers consider it for sustainability reasons when installing solar panels. Lastly, hand in hand with the exponentially increasing trend of mobile device usage, the intensity of electromagnetic radiation has increased as well. This radiation is mostly caused by the transportation of electricity and general use of electronic devices. In most regions of the Netherlands the degree of electromagnetism is below the maximum European guidelines. However, some tools that are being used closely to the body, such as household tools and building equipment with a relatively strong electromotor, exceed this maximum (Stam, Pruppers and Bolte, 2014). Furthermore, the RIVM reports that around ten thousand Dutch children live in areas with presumably increased chances of Leukaemia due to high-voltage lines. Taking these factors into account when building or renovating housing could prove to be beneficial for the overall health status, but also costly.

2.3.4. Crime and Violence

While having covered the most common forms of external environmental influences on health, a quite distinct form of negative external effects remains: the level of crime and vandalism in a neighbourhood. At first sight, this might not come across as a direct influencer of human health, however, for specific groups of society the effects turn out to be significantly large. Coakley and Williams (1979) discovered that especially for older people a burglary or other confrontation with crime or violence can have long lasting effects on health resulting in a wide spectrum of medical, surgical and psychiatric problems. In many cases such an event results in a major health crisis, with sometimes even admission to a hospital without the guarantee of full recovery as a result. The expectation in this thesis is that the effect of housing conditions is strengthened by residents' vulnerability and senescence.

2.4. Demographics and other variables

Besides the supposedly increased sensitivity of older people to their environment and hence to housing conditions, there could be more demographical factors influencing the relationship between housing conditions and health. In this paragraph we will dive into relevant literature in order to discover if there are any other demographics that influence health or the sensitivity to the environment the individuals are living in. This will allow us to control for these variables and make more sense of the final results.

In addition to the importance of taking into account a person's *age*, *gender* might be of significant interest to deepen the true relationship at hand. In general it is still the case that women spent, on average, a larger part of the day in their house than men partly due to the fact that they do not work as many hours as them. Despite some equalization in the last years, average Dutch men work 38 hours per week while women work 26 hours (CBS, 2017) exposing them to housing conditions for a longer time period. However, even after controlling for this, women tend to be more sensitive to housing conditions where the need for major renovation results in a 22 percent increase of doctor visits (Aydin et al., 2017).

Household composition could also be a factor influencing the health level of residents within one house. There is, for example, evidence of the fact that households with middle-aged females provide better healthcare for both children and the elderly (Wallace, Mendez-Luck & Castañeda, 2009; Schmid, Brandt, & Haberkern, 2012; Mudrazija, López-Ortega, Vega, Robledo & Sribney 2016). Other studies have shown that people living with a partner experience higher social support and higher psychological well-being in comparison to people living without a partner (Gove, Hughes & Style, 1983; Kawachi & Berkman, 2001; August & Sorkin, 2010). Therefore, *marital status* is another demographic factor for which significant differences could be expected. This is highlighted by the fact that people living with another adult which is not their partner feel a higher level of support, than people living alone, but more surprisingly is the finding that their psychological well-being is substantially worse than that of individuals living alone (Joensen et al., 2017).

Two other factors with an undeniable link to health are *income* and *education*. Benzeval and Judge (2001), wrote a review in which they described a vast amount of papers resulting in evidence of the fact that income is positively related to health while long term poverty has detrimental consequences for health. As a result of this, it is safe to assume that well-educated individuals have, on average, a higher health-level due to the high correlation and causality

between education and income (Adams et al., 2003; Akgüç, 2011). In addition, people with lower income are more likely to reside to rental housing, which is often less well-maintained than owner-occupied housing (Pollack, von dem Knesebeck & Siegrist, 2014). In line with the argument of time spent in and around the house it becomes evident that the influence of *labour force status* leading to differences in exposure to someone's housing conditions should also be taken into account.

Furthermore, a part of someone's level of mental well-being can be dedicated to their perception of space and freedom. The size of a house and the amount of people that area is shared with might affect someone's level of happiness and therefore their emotional prosperity. According to Foye (2017), there is a slight positive relationship between the size of living space, calculated by dividing the amount of rooms by the amount of people living in a house, and subjective well-being. This effect is only apparent for men, arguably due to the fact that a larger house signals a degree of status for which men tend to be more sensitive than women.

Finally, it is of utter importance to keep several obvious influencers of health in mind such as smoking behaviour, drinking habits and BMI. A healthy BMI is considered as an indicator of good health behaviour in various articles on health economics (Reinhold & Jürges, 2010; Künn-Nelen, 2016) while excessive smoking- and drinking behaviour is well-known to have a negative impact on health.

2.5. Conclusion and sub questions

This literature review has provided the necessary information on the fields of interest for setting up our own research model. The specifics on topics such as health and housing conditions have been explored while simultaneously taking into account external factors and demographics influencing a possible relationship. The remainder of this thesis will attempt to combine the available knowledge with the utilization of the LISS dataset which will be introduced in the next sections. The objective will be to provide a sophisticated model in an effort to setup a framework for our relatively untouched research, filling the gap in the research field on owner-occupied Western housing conditions.

Recall the problem statement of this thesis:

"What is the effect of owner-occupied housing conditions on health?"

It is of importance to define this problem statement further in order to construct a model measuring the true effects. A first step in the right direction is the construction of subquestions that make our research objective more tangible. Based on the literature review, the following subquestions will be investigated:

- *What is the effect of owner-occupied housing conditions on general health perception?*
- *What is the effect of owner-occupied housing conditions on perceived happiness?*
- *What is the effect of owner-occupied housing conditions on activity hindrance (daily, social and work) by disease?*
- *What is the effect of owner-occupied housing conditions on the amount of yearly healthcare visits to doctors, psychologists and medical specialists?*

The purpose of these four questions is for each to cover a different health perspective. The independent variable *housing conditions* will be further elaborated on in the upcoming data section. Considering the dependent variables for health, *health perception* can be regarded as someone's general health status both physically and mentally. *Happiness*, on the other hand, captures a certain state of mental well-being. Moreover, *hindrance* involves the opportunity cost of poor health as previously elaborated on. Lastly, a more quantitative measure of a person's health is their usage of healthcare facilities where we distinguish between *visits to doctors, psychologists and medical specialists* as we believe these are the three most dominant and overarching providers of healthcare.

The last two health indicators enable a direct link to costs. On the one hand, *hindrance* will be used as an indicator of negative economic benefit through productivity loss. On the other hand, *healthcare visits* is the variable that can be directly linked to healthcare costs because these two typically move in the same direction. In the methodology and analysis, both hindrance and healthcare usage will be elaborated on since they possess more objective value than health perception and happiness.

Based on previous findings, the expectation is that housing conditions should indeed have an effect on the general health perception, happiness, hindrance of activities on a daily, social and work related level and could cause both physical and mental health problems resulting in an increased amount of healthcare facility visits. However, these relations are unlikely to all be significant and equally large. Within the sub questions, a ranking will be created in an attempt

to link specific dwelling problems to health problems and thereby establish some kind of causal relationship.

Besides the four main sub questions, insights from existing research indicating the importance of a healthy external environment suggest that there might be an interaction effect between housing conditions and the external environment. Consider, for example, an individual that experiences a very noisy surrounding environment. For that individual's health to suffer from this noise, the dwelling plays a key role. For the purpose of capturing these kind of effects, environmental factors will be controlled for.

Supposing that health indeed appears to be impacted by housing quality, the value of renovation is highly likely to increase as a result of healthy building. Needless to say, housing renovations are oftentimes an expensive endeavour. After answering the individual sub questions, we will discuss a trade-off between the costs of solving housing problems and the benefits in the long run. An important aspect to take into account is the effect of a renovation on the WOZ-value (Waardering Onroerende Zaken). The WOZ-value is a Dutch indicator of property valuation. Since the owner of a property is the sole person responsible for renovation, the costs will also be his to carry. Therefore, an owner is expected to only renovate if the benefit of a healthier house in combination with the increase in WOZ-value is greater than the renovation costs. It is possible that people, for instance, feel responsible for reducing Dutch healthcare costs or have the urge to renovate for sustainability reasons so in individual cases there could be a perceived social benefit aspect taken into account when renovating. The following equation visualizes the trade-off under which an individual is expected to renovate

$$\Delta Health\ status + \Delta WOZvalue + \Delta Perceived\ social\ benefit > Renovation\ costs$$

Whether there is a WOZ-value benefit from renovating will be analysed by posing the question:

- *What is the effect of owner-occupied housing conditions on WOZ-value?*

In case a relation between WOZ-value and housing problems will be found, it might be insightful to review the housing developers' business model. According to Bocken, Short, Rana and Evans (2014), a business model can be decomposed into three parts: (1) Value proposition, (2) Value creation and delivery and (3) Value capture. Figure 4 describes what activities characterize each part of the business model. In the discussion section we will reflect back on the upcoming analysis to gain more insights on what the strategic implications of the results are

and which stakeholders will be responsible for change. Perhaps a shift in the business model is necessary?

Figure 4: Conceptual business model framework (Bocken et al., 2014)

3. Data and Methodology

In the upcoming sections, the LISS dataset will be introduced and summarized based on descriptive statistics. After elaborating on LISS, we will examine the descriptive statistics on a general level. Next, the tenants will be excluded from the dataset in order to describe the owners and their summary statistics. Along the way, the variables will be clearly described. Finally, an empirical strategy on which the results will be based is presented.

3.1. The LISS dataset

The objective of this thesis is to assess the relationship between housing conditions and health within the Netherlands. Therefore, the LISS (Longitudinal Internet Studies for the Social sciences) panel dataset will be used. Since October 2007, it has been the principal component of the Measurement and Experimentation in the Social Sciences (MESS) project consisting of 4,500 households and around 7,000 individuals. The households are drawn from the population register maintained by Statistics Netherlands. The LISS dataset is built up by different questionnaires consisting of varying topics for which the respondents get a financial compensation. The conducting organization, CentERdata, aims at collecting data for each individual at least once a year, in so called “collection waves”, and over an as long time horizon as possible in order to enable researchers to analyze trends. The consistency of the LISS dataset is both a challenge and an opportunity for establishing a final version suitable for panel regression. It consists of several modules all combining the different collection waves through manual allocation. However, the collection periods of the modules differ substantially which

demands for the construction of a lag effect. This will be covered more thoroughly in the methodology section. The main modules that will be used for our analysis are the following:

- *Health*
- *Social integration and Leisure*
- *Family and Household*
- *Work and Schooling*
- *Personality*
- *Economic situation: Income*
- *Economic situation: Housing*

The Health module will be regarded as the basis of our sample. In other words, any responses that have been collected for other datasets (e.g. Family and household, Housing, Personality) but not for Health in a certain year have not been used keeping the dataset as representative as possible. Since the amount of observations of children below 16 years old is negligible, they have been excluded from the dataset resulting in a minimum age of 16 and a maximum age of 98. A total of 12,159 unique respondents can be identified within the dataset where some of them have been a participant for many years while others have responded to the LISS survey only once. When compiling all the responses from all the unique respondents we were able to establish a dataset containing 52,134 observations with an individual respondent/wave combination. A simple calculation tells us that, on average, a respondent has been in the dataset for 4.29 waves. For 2,001 respondents data can be extracted for all nine collection waves.

As the research question already hints at, this study will focus on "owner-occupied" housing, meaning that the occupant bought the house, while a parallel study will put emphasis on "rental housing" in the aim of finding out whether the same logic applies for both groups of residents. Inhabitants of rental housing generally suffer more from health issues since rental houses are less well-maintained than owner-occupied houses (Frijters, Haisken-DeNew, & Shields, 2005). Despite these findings, more than 56 percent of the Dutch houses are owner-occupied (CBS, 2017) meaning that the health status of owners can apply substantial pressure on healthcare costs if it turns out to be subjective to housing quality. Moreover, home owners usually feel more responsible for renovating their property since they will, on average, be living there for a longer period. Besides, they have more freedom to maintain and refurbish their house while simultaneously having more funds to do so; the average income of tenants is substantially lower than that of owners. Consequently, more serious implications might be the case for tenants.

Aforementioned division requires a further narrowing down of the initital data set after the descriptives have been presented. In the next section, the summary statistics will be presented for the entire sample. After that, some descriptive statistics will be given only involving the observations for owners. This will eventually be the final dataset for the remainder of the analysis.

3.2. General descriptive statistics

Table 2.1 depicts the summary statistics of the entire dataset including both (sub-)tenants and (co-)owners. Overall, around 16 percent of the respondents reported poor health, indicated by a general health perception score of either 1 or 2 out of 5. Slightly higher proportions can be derived from the hindrance variables where around 20 to 25 percent of the respondents experiences hindrance from disease, for different activities. It is interesting to see that the average satisfaction level of dwellings lies around an eight out of ten while, simultaneously, 23 percent of all participants report at least one problem with their dwelling.

	Mean	Std. Dev.
Health		
General health perception (1-5)	3.12	0.77
Bad/Poor health (1=yes)	0.16	-
Happiness (0-10)	7.57	1.28
Healthcare utilization (in the last year):		
Visits to a general practitioner	2.31	4.33
Visits to a psychologist or psychiatrist	0.68	5.11
Visits to a medical specialist	1.36	3.82
Hindrance as a result of health status:		
Daily activity hindrance	0.23	0.42
Social hindrance	0.19	0.40
Work hindrance	0.24	0.43
Dwelling Characteristics		
Dwelling satisfaction (0-10)	7.95	1.49
Dwelling problems (1=yes):		
Too small	0.07	-
Too dark	0.02	-
Inadequate heating	0.03	-
Leaking roof	0.02	-
Damp walls or floors	0.04	-
Rotten windowframes or floors	0.03	-
Too noisy	0.12	-
No problems at all	0.77	-
Number of rooms	4.36	1.45
Amount of monthly rent (in euros)	508.30	210.81
Recent WOZ value of the dwelling (in euros)	303,654	1,032,987
Dwelling Typology:		
Single family home - Detached (1=yes)	0.14	-
Single family home - Corner lot (1=yes)	0.14	-
Single family home - Duplex house (1=yes)	0.14	-
Single family home - Row house (1=yes)	0.29	-
Apartment (1=yes)	0.23	-
Other (1=yes)	0.07	-

Table 2.1: Descriptive statistics full dataset (incl. main dependent and independent variables)

The dwelling problems that will be focused on are: *(1) too small, (2) too dark, (3) inadequate heating (or too cold), (4) leaking roof, (5) damp walls or floors, (6) rotten window frames or floors* and *(7) too noisy*. These seven different housing problems will be grouped even further into three categories being *(1) comfort problems* involving problems that are not directly

associated with health problems but could lead to a lower degree of comfort, *(2) hazardous problems* involving problems that are known to cause health issues and *(3) noise problems* which will be regarded as a separate category partly because of the extensive research already done by Weinhold (2016). This categorization is based on cross-tabulation and intuition. Appendix A.1, contains a tabulation of how often each problem occurs in conjunction with another specific problem. One can conclude that the likelihood of hazardous problems occurring together is higher than other problems occurring together, hence justifying the categorization. Figure 5, summarizes the categorization which will be a focal element for the rest of this thesis.

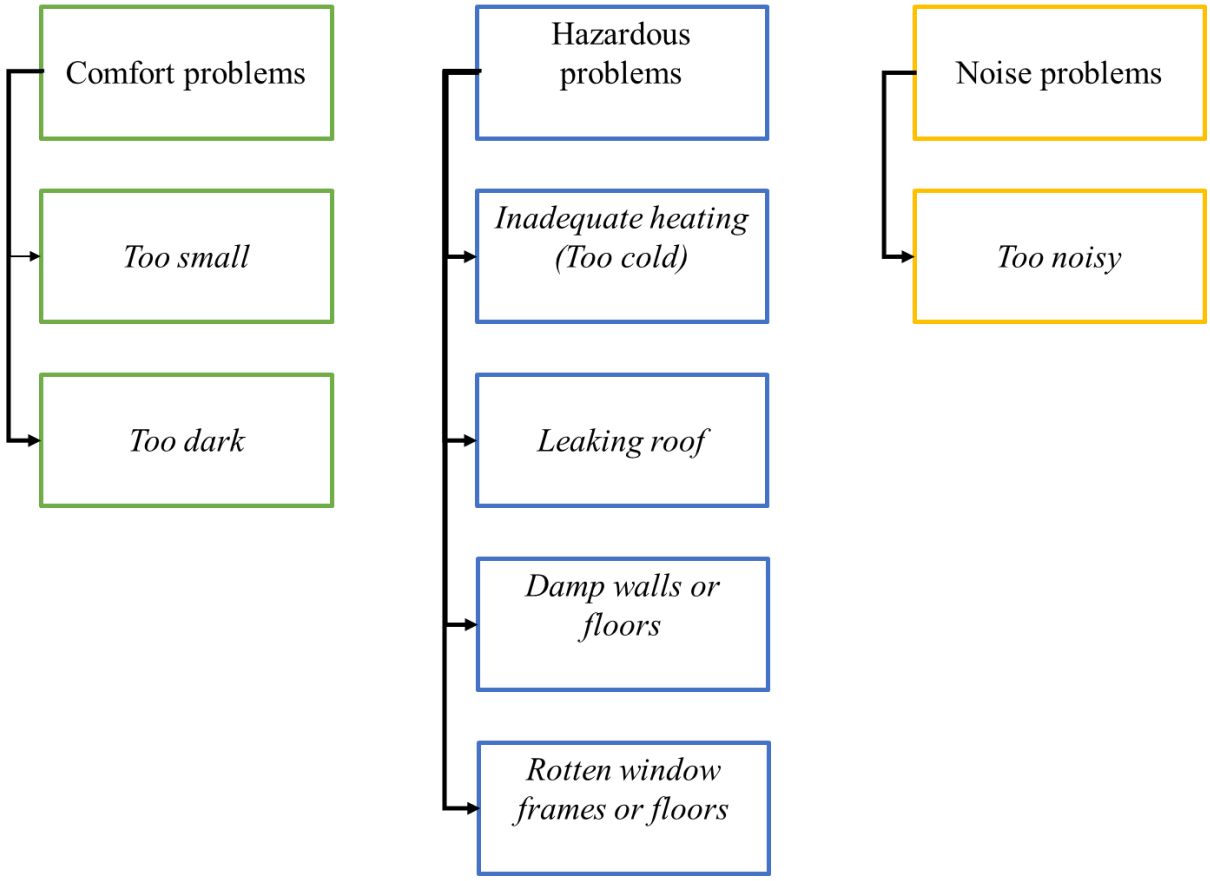

Figure 5: Categorization of specific problems from the LISS dataset

By zooming out to external, household and respondent characteristics table 2.2 has been constructed. These summary statistics aim at providing a better understanding of the underlying fundamentals of the dataset at hand. 33 percent of responses state vicinity problems mostly consisting of noise issues, related to both neighbour and urban noise. Of all the respondents, 31 percent is a tenant while 67 percent claims being owner. 2 percent of the respondents falls in none of the two groups indicating that they most likely inhabit a squatted building which they

neither rent nor own. 43 percent of the households has at least one child living at home with an average of 0.86 children living in each household. 53 percent of all respondents is occupied with paid employment and 9 percent follows a form of education, thereby characterizing themselves as students.

	Mean	Std. Dev.
External Environment Characteristics		
Vicinity satisfaction (0-10)	7.76	1.53
Vicinity problems:		
Neighbour noise annoyance (1=yes)	0.21	-
Street noise annoyance (1=yes)	0.11	-
Stench, dust or dirt (1=yes)	0.05	-
Vandalism or crime (1=yes)	0.08	-
None of these (1=yes)	0.67	-
Household Characteristics		
Monthly net household income (in euros)	2,944.79	5,259.35
Individual is a tenant or sub-tenant (1=yes)	0.31	-
Individual is a homeowner (1=yes)	0.67	-
Individual receives rent benefit (1=yes)	0.35	-
Household size	2.65	1.32
Ratio household members per room	0.54	0.30
Respondent regularly resides elsewhere (1=yes)	0.02	-
Respondent moved ever (1=yes)	0.24	-
Partner (1=yes)	0.77	-
Living together with partner (1=yes)	0.70	-
Married (1=yes)	0.58	-
Household with children (1=yes)	0.43	-
Number of children	0.86	1.15
Respondent Characteristics		
Gender (1=male)	0.46	-
Age of respondent	48.93	17.28
Health characteristics:		
Individual smoked ever (1=yes)	0.58	-
Individual currently smokes (1=yes)	0.20	-
Frequent_Drinker (> twice a week) (1=yes)	0.33	-
Individual practices sports (1=yes)	0.53	-
Respondent BMI	25.43	4.53
Individual is working (1=yes)	0.53	-
Individual is studying (1=yes)	0.09	-
Individual holds a higher education degree (1=yes)	0.27	-

Table 2.2: Descriptive statistics full dataset (continued)

Even though the probabilities of the occurrence of different health problems has been discussed, not every respondent will have the same probability of experiencing poor health or housing problems. Moreover, each respondent's environment and background differs, resulting in systematically different outcomes. The existing literature already hints to age and income being determinants of health. Appendix A.2 compares two scenario's; one where no housing problem is observed and the other where at least one housing problem is observed. In order to catch the influence of age and income, they have been divided in quartiles. Furthermore, a distinction has been made between owners and tenants since a similar intuition applies to both groups due to their varying age and income.

Aforementioned analysis has been carried out five times to match our five health indicators presented in panels A through E: general health perception, proportion with poor health, happiness, yearly healthcare visits (doctor, psychologist, medical specialist) and percentage of hindrance. In line with our expectations, all indicators point towards a similar direction; young people with a high household income and home ownership generally experience a better health. However, people in the first and last age quartile seem to be slightly happier than respondents in the two middle quartiles, possibly as a result of work stress and anxiety (Thomas et al., 2016). In addition to this, the presumably devastating health effects of housing problems are apparent for all health indicators and are visible regardless of age, household income or ownership status. Even though, the effects for owners and tenants seem to be of similar magnitudes, one can clearly observe that health is substantially better for the first group compared to the latter on all indicators. Could this be partly explained by the fact that owners experience less problems than tenants?

	Respondent Age				**Household Net Income (annual)**				**Ownership Status**	
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	(Sub-)Tenant	(Co-)Owner
Dwelling satisfaction	7.39	7.67	8.06	8.37	7.82	8.01	8.12	8.29	7.39	8.22
No problem	64%	72%	80%	87%	71%	76%	83%	86%	61%	85%
Problem	36%	28%	20%	13%	29%	24%	17%	14%	39%	15%
Comfort problems	18%	12%	5%	3%	10%	8%	6%	6%	15%	5%
Hazardous problems	13%	11%	9%	6%	12%	10%	6%	6%	15%	6%
Noise problems	19%	14%	12%	7%	18%	12%	8%	6%	24%	7%

Table 3: Dwelling satisfaction and occurrence of problems by Age, Household income and ownership status

Table 3 depicts both the amount of problems and the problem categories within each age- and income quartile. The results are in line with general expectations of younger people with lower incomes experiencing problems more often. Moreover, important for the question at hand is

that the difference in problem occurrence between owners and tenants has been reported as well. It appears that owners rate their dwelling satisfaction almost a full point higher than tenants. Besides, 85 percent of the owners does not experience any problems compared to 61 percent of the tenants, and for each problem category (comfort, hazardous and noise) the same logic applies. Hence, it could be possible that owners are in general more happy than tenants because they experience less housing problems at once. Despite this, by recalling Appendix A.2 one can still observe that owned homes which are subjective to dwelling problems are nevertheless experiencing lower health indicators. Does this effect merely stem from characteristics like age, income and other demographics or is it possible to directly link housing conditions to owner health as well? Are home owners willing and able to sufficiently invest in their housing quality to erode any health effects? These are the questions of interest for our research topic. Therefore, from now on the dataset will only contain owners and co-owners.

3.3. Home-owner descriptive statistics

This section of the report will clarify the characteristics of the owners in the LISS dataset and sketch a fundamental basis on which the empirical strategy will be built. Appendix table B.1 displays the most rudimentary statistics underlying home-owners. Monthly household income is approximately 12 percent lower for households experiencing one type of dwelling problem compared to households living in problem-free houses. When experiencing multiple types of problems, income lies almost 17 percent lower. The same logic applies for the WOZ-value (Waardering Onroerende Zaken) of buildings which is significantly higher for dwellings without problems. Problematic houses, furthermore, tend to be slightly smaller in combination with larger households and more children living at home. The average age of individuals living in problem-free homes is almost five years higher than that of the owners of problematic houses. This is in line with the results for age and income in section 3.2. Most problems occur in single family row houses and apartments, accounting for more than half of all occurrences. Lastly, a degree of correlation can already be observed between problem occurrence and the external environment. In other words, whenever there is a dwelling problem, it becomes more likely that there are also issues in the external environment and vice versa. For example, the table indicates that in case of multiple dwelling problems there is at least one issue in the external environment in 75 percent of the cases. This is once more a confirmation that these factors should be controlled for in the upcoming analysis to ensure robustness.

Table B.2's results (Appendix B) are in line with the previous owner characteristics, even though some differences among the varying types of problems can be detected. Comfort problems occur mostly as a result of small housing with a lower WOZ-value and lower number of rooms inhabited by younger people. Hazardous problems appear to be occurring across all types of dwellings and are the least correlated with the external environment in comparison to the noise and comfort categories, which makes intuitive sense. As expected, noise problems are closely related to neighbour and street noise and apply to individuals with a lower average household income of which 65 percent lives in either a row house or an apartment.

Thus, it could be possible that the relationship between housing and health is solely driven by socio-economic factors influencing both dependent and independent variables and thereby causing a substantial degree of statistical noise. The remainder of this thesis will focus on discovering whether there is a true causal relationship between housing conditions and health.

3.4. Empirical strategy

In order to answer the problem statement, a similar OLS equation to Aydin et al. (2017) will be used given below.

$$Health^{*}_{i,d,t} = \beta Housing\ Condition_{i,d,t-1} + \lambda X_{i,t} + \delta Z_{d,t} + \alpha_i + t_t + \varepsilon_{i,d,t}$$

The dependent variable in this formula is $Health^{*}_{i,d,t}$ which involves the health status of individual *i,* living in dwelling *d* in year *t.* Over the course of this research, this variable will consist of several measures namely *percentage with bad health, general health perception*, *happiness*, *yearly healthcare visits* and *hindrance*. The main independent variable $\beta Housing\ Condition_{i,d,t-1}$ stands for the conditions of the dwelling *d* at time *t-1.* A lag has been created to effectively capture the impact of housing quality in the previous wave on the health indicators in the following wave. This variable will consist of dummy variables related to the several dwelling problems in the dataset. Over the course of this research we will make use of a general problem dummy at first. Next, the three categories will be regressed and this will be narrowed down further into the seven specific problems mentioned before. Gender and age differences will be taken into account in later regressions. Finally, the health indicator *healthcare visits* will be split into (1) *general practitioner,* (2) *psychologist, psychiatrist, psychotherapist* and (3) *medical specialist* in an attempt to pinpoint more specific relationships between certain housing conditions and the healthcare usage they are related to the most.

Moreover, the vector $X_{i,t}$ includes all individual control variables such as income and BMI and $Z_{d,t}$ involves housing control variables. Further inclusion of time-invariant idiosyncratic effects, time (year) fixed effects and an error term with normal distribution allow for β representing the effect of housing conditions on an individual's health status, hence being the parameter of interest. The results of the regressions will be examined next.

4. Results

In this section the results following from the methodology will be presented and elaborated on. For convenience, selected parts of each table will be presented in the text containing only the dwelling condition as an independent variable, while the complete versions can be found in Appendix C.

4.1. Effect of at least one housing problem on health indicators

First of all, the simple observation of a dwelling having a problem regardless of type will be investigated. Table 4 portrays a selection of this OLS regression. In general, a significant relationship between having at least one housing problem and the health indicators can be observed even after excluding respondents that moved during the collection period or regularly reside elsewhere. People experiencing a housing problem are almost 6 percent more likely to report poor health. Moreover, their general health perception is around 0.10 points lower than problem-free people and they are less happy at a 10 percent significance level. Furthermore, when facing dwelling problems people tend to visit a healthcare facility more than 0.5 additional times while they feel roughly 11 percent more hindered by disease.

	Bad Health (1=yes)	Bad Health (1=yes)	Health perception (1-5)	Health perception (1-5)	Happiness (0-10)	Happiness (0-10)	Healthcare visits	Healthcare visits	Hindrance (%)	Hindrance (%)
Housing problem (t-1) (1=yes)	0.057***	0.058***	-0.126***	-0.108***	-0.106**	-0.096*	0.530**	0.549**	0.088***	0.114***
	(0.001)	(0.003)	(0.000)	(0.005)	(0.028)	(0.082)	(0.015)	(0.036)	(0.000)	(0.000)
Observations	17047	13152	17047	13152	14070	10841	17047	13152	17047	13152
R-squared	0.080	0.078	0.127	0.125	0.201	0.212	0.062	0.071	0.064	0.070
Number of individuals	4678	3882	4678	3882	3965	3055	4678	3882	4678	3882
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
Movers excluded	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

*** Significantly different from 0 at 1 percent level. ** Significantly different from 0 at 5 percent level. * Significantly different from 0 at 10 percent level.

Table 4: Effect of having at least one housing problem on health indicators (full table in App. C.1)

More insightful would be to determine which problem category contributes to the previously depicted significant relationships. Therefore, in table 5 the three problem categories have been incorporated in the regression. One can conclude that having comfort problems, a dwelling either or both being too small or too dark, significantly results in an extra healthcare visit per year and an approximately 10% higher degree of hindrance. This is the first evidence that comfort problems could therefore be regarded as possible drivers of healthcare costs in the Netherlands. More convincing results can be observed for the hazardous problems which have a significant effect on all the health indicators except for happiness. This means experiencing at least one of the four hazardous housing problems influences both a person's perception of their health as well as their explicit cost drivers, being healthcare visits and hindrance. Furthermore, the effects are stronger than in the circumstance of comfort problems, except for healthcare visits. Contrary to Weinhold's (2016) findings, noise problems do not seem to have an effect on the health indicators but this is most probably the result of controlling for vicinity noise and dwelling type. Appendix B.2 confirms this hypothesis by visualizing that a dwelling being *too noisy* is accompanied by a noisy vicinity 64 percent of the time. When these controls are excluded, a positive relationship between noise problems and hindrance can be observed. Residents appear to be 9 percent more hindered when experiencing an environment that is perceived as *too noisy*. Moreover, noise problems are mainly apparent in apartments and row houses for which has been controlled as well.

	Bad Health (1=yes)	Bad Health (1=yes)	Health perception (1-5)	Health perception (1-5)	Happiness (0-10)	Happiness (0-10)	Healthcare visits	Healthcare visits	Hindrance (%)	Hindrance (%)
Housing problem category (t-1)										
Comfort problems (1=yes)	0.040	0.064*	-0.088	-0.061	0.005	-0.078	0.643*	1.065**	0.055	0.094**
	(0.149)	(0.063)	(0.100)	(0.368)	(0.951)	(0.424)	(0.072)	(0.022)	(0.109)	(0.030)
Hazardous problems (1=yes)	0.084***	0.096***	-0.184***	-0.169***	-0.110	-0.019	0.635**	0.849**	0.078***	0.121***
	(0.000)	(0.001)	(0.000)	(0.002)	(0.107)	(0.806)	(0.038)	(0.022)	(0.008)	(0.000)
Noise problems (1=yes)	0.010	0.004	-0.008	-0.024	-0.062	-0.046	0.058	-0.253	0.057*	0.049
	(0.666)	(0.881)	(0.858)	(0.655)	(0.361)	(0.557)	(0.851)	(0.489)	(0.054)	(0.149)
Observations	17047	13152	17047	13152	14070	10841	17047	13152	17047	13152
R-squared	0.081	0.080	0.129	0.126	0.201	0.211	0.063	0.062	0.064	0.070
Number of individuals	4678	3882	4678	3882	3965	3055	4678	3882	4678	3882
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
Movers excluded	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

*** Significantly different from 0 at 1 percent level. ** Significantly different from 0 at 5 percent level. * Significantly different from 0 at 10 percent level.

Table 5: Effect of different housing problem categories on health indicators (full table in App. C.2)

Next, the most detailed distinction of housing problems will be described consisting of the seven specific housing problems on an individual level. Table 6 presents a regression similar to the previous two tables but allows for an even more precise allocation of relationships. The first

interesting observation is that the only comfort problem portraying significant coefficients is a dwelling being *too dark* hinting towards the fact that this is also the driver of aforementioned increased healthcare visits through comfort problems. There is, however, an indication that the ratio "residents per room", which is an objective measure for housing size, significantly decreases happiness (Appendix C.3). More specifically, dwellings lacking light decrease the happiness score by approximately half a point while increasing the amount of yearly healthcare visits by three. Regarding hazardous problems, dwellings with *inadequate heating* and a *leaking roof* seem to increase the likelihood of experiencing poor health. In addition, occurrences of a *leaking roof* and *rot* are the only two hazardous problems significantly increasing healthcare visits by 2. and 1.5, respectively.

	Bad Health (1=yes)	Bad Health (1=yes)	Health perception (1-5)	Health perception (1-5)	Happiness (0-10)	Happiness (0-10)	Healthcare visits	Healthcare visits	Hindrance (%)	Hindrance (%)
Specific dwelling problems (t-1)										
Too small (1=yes)	0.019	0.052	-0.077	-0.079	0.171*	0.120	-0.047	-0.088	0.031	0.083
	(0.546)	(0.213)	(0.211)	(0.331)	(0.063)	(0.304)	(0.910)	(0.873)	(0.437)	(0.111)
Too dark (1=yes)	0.107**	0.090	-0.139	-0.055	-0.442***	-0.544***	1.89***	3.122***	0.092	0.103
	(0.024)	(0.116)	(0.132)	(0.617)	-0.001	(0.001)	(0.002)	(0.000)	(0.121)	(0.150)
Too cold (1=yes)	0.104**	0.153***	-0.015	0.044	0.137	0.195	0.423	0.208	0.105*	0.104
	(0.017)	(0.003)	(0.859)	(0.657)	(0.276)	(0.173)	(0.450)	(0.758)	(0.052)	(0.104)
Leaking roof (1=yes)	0.054	0.137**	-0.173*	-0.284**	-0.126	-0.122	1.415**	2.128***	0.078	0.078
	(0.247)	(0.018)	(0.058)	(0.012)	(0.352)	(0.461)	(0.020)	(0.006)	(0.183)	(0.286)
Damp walls and floors (1=yes)	0.025	0.025	-0.134*	-0.170*	-0.057	0.014	-0.360	-0.072	0.033	0.104*
	(0.507)	(0.583)	(0.069)	(0.053)	(0.604)	(0.913)	(0.465)	(0.904)	(0.494)	(0.065)
Rotten window frames or floors (1=yes)	0.065*	0.011	-0.212***	-0.131	-0.163	-0.029	1.284***	1.466**	0.069	0.091
	(0.087)	(0.814)	(0.004)	(0.136)	(0.139)	(0.823)	(0.009)	(0.015)	(0.144)	(0.107)
Too noisy (1=yes)	0.007	0.000	0.000	-0.019	-0.058	-0.054	0.002	-0.305	0.052*	0.047
	(0.781)	(0.994)	(1.000)	(0.718)	(0.397)	(0.484)	(0.996)	(0.404)	(0.078)	(0.170)
Observations	17047	13152	17047	13152	14070	10841	17047	13152	17047	13152
R-squared	0.083	0.083	0.130	0.127	0.205	0.215	0.067	0.080	0.065	0.070
Number of individuals	4678	3882	4678	3882	3965	3055	4678	3882	4678	3882
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
Movers excluded	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

*** Significantly different from 0 at 1 percent level. ** Significantly different from 0 at 5 percent level. * Significantly different from 0 at 10 percent level.

Table 6: Effect of specific housing problems on health indicators (full table in App. C.3)

A summary of all the significant relationships has been visualised in appendix C.4. Only the significant links are presented where green borders indicate a positive interaction and red borders a negative one. Moreover, a dashed line indicates a significance level of 10 percent while solid lines point towards a more significant relation with p-values below 5 percent.

4.2. Economic cost drivers: Hindrance and healthcare visits

Since the main objective of this thesis is to investigate how healthcare costs are driven by housing conditions and what the economic impact of disease is, this section will further analyse

the two main drivers of costs being (1) the percentage of people hindered by disease as an indicator of productivity loss and therefore negative economic consequences and (2) the amount of yearly healthcare visits which can be regarded as a direct driver of healthcare costs. In the following paragraphs, a deeper understanding of the impact of housing conditions on both cost drivers will be established with a focus on differences in gender and age. Consequently, an analysis involving the different types of healthcare facilities will be done.

4.2.1. Hindrance effects by gender

Tables 7 and 8 present regressions of all housing problems against hindrance and healthcare visits respectively. The even columns represent the results for a sample consisting solely of males while the odd columns incorporate females only. Appendix D contains the full versions of the upcoming tables. The regressions in table 7 provide evidence of hindrance from disease of approximately 10 percent more when experiencing a problem, regardless of gender. A cautious conclusion that could be drawn here is that people experiencing housing problems are 10 percent more hindered resulting in an economic opportunity costs increase of 10 percent as a result of productivity loss. The main assumption, however, is that people that are hindered by disease are not able to work or provide economic benefit to a country and are therefore cost drivers. Interesting is the fact that males seem to be extremely sensitive to comfort problems with an 18 percent higher probability of being hindered by disease especially stemming from *darkness*. For females, we fail to provide this evidence. However, there is no doubt that hazardous problems increase hindrance significantly for both men and women. While men seem to suffer the most from a dwelling being *too cold*, 17 percent more hindrance on a 5 percent level, women suffer 18 percent more from *rot* but this is only significant at a 10 percent level.

	Hindrance (%) (Male)	Hindrance (%) (Female)	Hindrance (%) (Male)	Hindrance (%) (Female)	Hindrance (%) (Male)	Hindrance (%) (Female)
Housing problem (t-1)	0.106***	0.114***				
	(0.001)	(0.003)				
Housing problem category (t-1)						
Comfort problems (1=yes)			0.183***	0.007		
			(0.001)	(0.926)		
Hazardous problems (1=yes)			0.090**	0.131**		
			(0.047)	(0.018)		
Noise problems (1=yes)			0.033	0.070		
			(0.470)	(0.186)		
Specific dwelling problems (t-1)						
Too small (1=yes)					0.124*	0.107
					(0.064)	(0.209)
Too dark (1=yes)					0.247***	-0.128
					(0.008)	(0.261)
Too cold (1=yes)					0.167**	-0.005
					(0.030)	(0.968)
Leaking roof (1=yes)					0.004	0.131
					(0.968)	(0.275)
Damp walls and floors (1=yes)					0.060	0.106
					(0.461)	(0.189)
Rotten window frames or floors (1=yes)					0.036	0.178*
					(0.618)	(0.058)
Too noisy (1=yes)					0.031	0.064
					(0.501)	(0.231)
Observations	6583	6569	6583	6569	6583	6569
R-squared	0.082	0.093	0.086	0.092	0.087	0.096
Number of individuals	1943	1939	1943	1939	1943	1939
Socio-Economic controls	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES
Movers excluded	YES	YES	YES	YES	YES	YES

*** Significantly different from 0 at 1 percent level. ** Significantly different from 0 at 5 percent level.

* Significantly different from 0 at 10 percent level.

Table 7: Effect of housing problems on hindrance, male vs. female (full table in App. D.1)

4.2.2. Healthcare visits by gender

Table 8 has the same structure as table 7 with this time as a dependent variable investigating yearly healthcare visits. While there is no evidence for the effect of at least one housing problem on the amount of healthcare visits regardless of gender, a relationship becomes apparent when narrowing down. Both comfort problems as well as hazardous problems lead to an extra healthcare visit per year, however at a 10 and 5 percent significance level respectively. Regarding specific problems, the same relationship as in table 7 seems to apply. Males visit a

healthcare facility approximately 3 extra times on a yearly basis when their dwelling is suffering from a *lack of light* or a *leaking roof.* Females, on the other hand, visit a healthcare facility 2.8 extra times when their dwelling is *too dark* and 2 extra times whenever *rot* occurs. Recalling table 7, these effects seem to affect hindrance in a similar way for each gender group. When consulting research from the medical field there is, on the one hand, indeed evidence that women tend to be more allergic to certain substances than men (Jackson et al., 2001). On the other hand, women typically have a more resistant immune system possibly enabling them to cope with leaks and inadequate heating more easily. Research has proven that testosterone weakens the human immune system explaining small differences in sensitivity to cold and humid environments between men and women (Furman, 2013). The results seem striking when taking into consideration that an average problem-free owner visits a healthcare facility 3.61 times per year while some housing problems almost double this amount.

Even though the evidence suggests that a dwelling being perceived as *too small* has no serious implications for healthcare visits, Appendix D.1 argues that females go to a healthcare facility 4 to 5 extra times when the ratio of household members per room increases by 1. The results are highly significant and therefore provide valuable proof for the value of housing renovations in an attempt to lower healthcare costs, especially for certain dwelling problems at hand like darkness, inadequate heating, leakages and rot.

	Healthcare visits (Male)	Healthcare visits (Female)	Healthcare visits (Male)	Healthcare visits (Female)	Healthcare visits (Male)	Healthcare visits (Female)
Housing problem (t-1)	0.411	0.467				
	(0.247)	(0.226)				
Housing problem category (t-1)						
Comfort problems (1=yes)			1.190*	0.840		
			(0.055)	(0.235)		
Hazardous problems (1=yes)			1.079**	0.268		
			(0.030)	(0.628)		
Noise problems (1=yes)			-0.427	-0.319		
			(0.399)	(0.549)		
Specific dwelling problems (t-1)						
Too small (1=yes)					0.282	-0.320
					(0.701)	(0.707)
Too dark (1=yes)					2.815***	2.779**
					(0.007)	(0.014)
Too cold (1=yes)					0.390	-0.220
					(0.643)	(0.852)
Leaking roof (1=yes)					3.320***	0.566
					(0.002)	(0.636)
Damp walls and floors (1=yes)					-0.127	-0.329
					(0.887)	(0.685)
Rotten window frames or floors (1=yes)					0.901	2.062**
					(0.252)	(0.028)
Too noisy (1=yes)					-0.562	-0.336
					(0.267)	(0.528)
Observations	6583	6569	6583	6569	6583	6569
R-squared	0.090	0.095	0.094	0,0952	0,1010	0,1028
Number of individuals	1943	1939	1943	1939	1943	1939
Socio-Economic controls	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES
Movers excluded	YES	YES	YES	YES	YES	YES

*** Significantly different from 0 at 1 percent level. ** Significantly different from 0 at 5 percent level.

* Significantly different from 0 at 10 percent level.

Table 8: Effect of housing problems on yearly healthcare visits, male vs. female (full table in App. D.2)

4.2.3. Hindrance effects by age

Section 2.4. on demographics has already provided the evidence that older people's health in general can be perceived as worse than that of younger people. Moreover, whenever a housing problem occurs, the elderly tend to be affected more extremely than the younger respondents (Appendix A.2). In order to break down this interaction even further, in the following two sections a similar analysis as above will be conducted but for age quartiles. The quartiles are divided as follows: (1) 16 – 43 years old, (2) 44 – 54 years old, (3) 55 – 65 years old and (4) 66 – 93 years old. Important to take into account is the fact that movers are excluded in the analysis.

Some age groups are prone to move or reside elsewhere more often than other age groups. The full versions of each table can be found in the appendix again.

Table 9 summarizes the regression results with hindrance as the dependent variable. The main conclusions from this table are that in Q3 and Q4 the percentage hindrance is more seriously affected by housing problems. More specifically, there is evidence that older people are significantly impacted by comfort and hazardous problems especially dwellings being *too small, too cold* or experiencing *damp walls and floors*. Interesting is the fact that people in age quartile 2 seem to be experiencing increased hindrance from noise problems.

	Hindrance (%) (Age Q1)	Hindrance (%) (Age Q2)	Hindrance (%) (Age Q3)	Hindrance (%) (Age Q4)	Hindrance (%) (Age Q1)	Hindrance (%) (Age Q2)	Hindrance (%) (Age Q3)	Hindrance (%) (Age Q4)	Hindrance (%) (Age Q1)	Hindrance (%) (Age Q2)	Hindrance (%) (Age Q3)	Hindrance (%) (Age Q4)
Housing problem (t-1)	0.048	0.102**	0.142***	0.116**								
	(0.399)	(0.032)	(0.001)	(0.028)								
Housing problem category (t-1)												
Comfort problems (1=yes)					0.036	0.023	0.184**	0.126				
					(0.677)	(0.763)	(0.025)	(0.323)				
Hazardous problems (1=yes)					-0.001	0.031	0.100*	0.221***				
					(0.990)	(0.642)	(0.087)	(0.002)				
Noise problems (1=yes)					0.054	0.143**	0.084	-0.045				
					(0.480)	(0.035)	(0.172)	(0.548)				
Specific dwelling problems (t-1)												
Too small (1=yes)									0.124	-0.047	0.249**	0.177
									(0.222)	(0.593)	(0.036)	(0.187)
Too dark (1=yes)									-0.172	0.195	0.119	-0.473
									(0.254)	(0.143)	(0.287)	(0.308)
Too cold (1=yes)									-0.029	-0.143	0.023	0.344***
									(0.951)	(0.249)	(0.846)	(0.002)
Leaking roof (1=yes)									-0.228	-0.187	0.211*	-0.176
									(0.608)	(0.164)	(0.072)	(0.254)
Damp walls and floors (1=yes)									0.064	0.120	0.017	0.362**
									(0.635)	(0.243)	(0.856)	(0.031)
Rotten window frames or floors (1=yes)									-0.143	0.201*	0.124	0.127
									(0.380)	(0.079)	(0.194)	(0.276)
Too noisy (1=yes)									0.066	0.153**	0.066	-0.039
									(0.391)	(0.024)	(0.288)	(0.601)
R-squared	0.068	0.192	0.099	0.109	0.068	0.193	0.100	0.115	0.078	0.207	0.104	0.122
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
Movers excluded	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

*** Significantly different from 0 at 1 percent level. ** Significantly different from 0 at 5 percent level. * Significantly different from 0 at 10 percent level.

Table 9: Effect of housing problems on hindrance, by age quartiles (full table in App. D.3)

4.2.4. Healthcare visits by age

Besides the economic cost of hindrance, table 10 describes how the direct healthcare costs are impacted by housing problems per age quartile. It is apparent that only age quartile 3 is significantly impacted by having at least one housing problem resulting in 0.8 extra yearly visits. When the analysis is deepened, we find a significant positive relationship between healthcare visits and hazardous problems for age Q3. On the specific problem-level there is proof that especially young people tend to visit healthcare facilities approximately 5 extra times per year when experiencing *darkness*. Moreover, positive links between *leakage* in Q3 and *rot* in Q1 with respect to healthcare visits are found.

	Healthcare visits (Age Q1)	Healthcare visits (Age Q2)	Healthcare visits (Age Q3)	Healthcare visits (Age Q4)	Healthcare visits (Age Q1)	Healthcare visits (Age Q2)	Healthcare visits (Age Q3)	Healthcare visits (Age Q4)	Healthcare visits (Age Q1)	Healthcare visits (Age Q2)	Healthcare visits (Age Q3)	Healthcare visits (Age Q4)
Housing problem (t-1)	0.856	0.725	0.767**	-0.627								
	(0.158)	(0.143)	(0.042)	(0.335)								
Housing problem category (t-1)												
Comfort problems (t-1) (1=yes)					1.685*	0.926	0.134	-0.249				
					(0.064)	(0.248)	(0.850)	(0.875)				
Hazardous problems (t-1) (1=yes)					0.139	0.091	1.399***	0.317				
					(0.194)	(0.897)	(0.005)	(0.726)				
Noise problems (t-1) (1=yes)					-0.531	0.083	0.538	-0.930				
					(0.516)	(0.908)	(0.304)	(0.319)				
Specific dwelling problems (t-1)												
Too small (1=yes)									0.376	-1.419	0.724	0.060
									(0.725)	(0.117)	(0.469)	(0.971)
Too dark (1=yes)									4.606***	5.341***	-0.643	-4.288
									(0.004)	(0.000)	(0.509)	(0.459)
Too cold (1=yes)									-1.823	0.759	0.540	-0.159
									(0.712)	(0.554)	(0.592)	(0.909)
Leaking roof (1=yes)									0.156	-1.177	4.705***	2.403
									(0.974)	(0.397)	(0.000)	(0.211)
Damp walls and floors (1=yes)									-0.693	0.671	-0.747	-0.688
									(0.625)	(0.529)	(0.348)	(0.743)
Rotten window frames or floors (1=yes)									4.443**	0.684	1.479*	0.707
									(0.010)	(0.565)	(0.066)	(0.625)
Too noisy (1=yes)									-0.777	0.142	0.281	-0.106
									(0.340)	(0.841)	(0.592)	(0.258)
R-squared	0.175	0.168	0.130	0.052	0.184	0.167	0.134	0.052	0.205	0.191	0.158	0.054
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
Movers excluded	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

*** Significantly different from 0 at 1 percent level. ** Significantly different from 0 at 5 percent level. * Significantly different from 0 at 10 percent level.

Table 10: Effect of housing problems on yearly healthcare visits, by age quartiles (full table in App. D.4)

4.2.5. Types of healthcare visits

It makes intuitive sense that different housing problems cause varying health issues and that not each problem is equally impactful on each type of healthcare visit. To provide a deeper insight in which problems lead to which types of healthcare usage, a distinction between three types of healthcare facilities has been made: (1) general practitioner (2) psychologist, psychiatrist, psychotherapist and (3) medical specialist at a hospital. Table 11 describes that hazardous problems is the only problem category that draws people to general practitioners significantly more often. According to the regression, this is mainly due to *rotten window frames or floors* with almost one extra visit each year. A totally different logic applies to psychological visits where, as a result of comfort problems, 0.7 extra visits per year are caused. Zooming in on the specific problems indicates that a dwelling that is considered *too dark* has an extremely strong effect on the amount of psychological visits with almost three extra visits per year. One could, however, argue that this might not be completely unambiguous since people that are already depressed might have the feeling that their dwelling is too dark leading to even more visits. However, further tests for reverse causality have proven that a lack of light is typical for row houses and apartments with 66 percent of all the occurrences in those two dwelling types. Therefore, we have reason to believe the problem *too dark* is more related to dwelling type than to a respondent's mental well-being. A house being either *too small* or *too noisy* seems to have

an opposite impact. Lastly, visits to a medical specialist are mainly fuelled by *a leaking roof*, with 1.3 extra visits on a yearly basis, and a dwelling being *too small*, with 0.6 extra visits but at a 10 percent significance level.

	General practitioner	General practitioner	General practitioner	Psychologist a.o	Psychologist a.o	Psychologist a.o	Medical specialist	Medical specialist	Medical specialist
Housing problem (t-1)	0.229*			0.070			0.252		
	(0.096)			(0.507)			(0.105)		
Housing problem category (t-1)									
Comfort problems (1=yes)		0.064			0.669***			0.333	
		(0.792)			(0.000)			(0.226)	
Hazardous problems (1=yes)		0.652***			-0.114			0.310	
		(0.001)			(0.444)			(0.161)	
Noise problems (1=yes)		-0.015			-0.359**			0.121	
		(0.938)			(0.014)			(0.579)	
Specific dwelling problems (t-1)									
Too small (1=yes)			-0.065			-0.577***			0.555*
			(0.822)			(0.009)			(0.093)
Too dark (1=yes)			0.263			2.906***			-0.092
			(0.515)			(0.000)			(0.838)
Too cold (1=yes)			0.309			-0.103			0.006
			(0.386)			(0.701)			(0.988)
Leaking roof (1=yes)			0.644			0.210			1.275***
			(0.114)			(0.494)			(0.006)
Damp walls and floors (1=yes)			0.428			-0.168			-0.331
			(0.175)			(0.478)			(0.354)
Rotten window frames or floors (1=yes)			0.897***			0.027			0.544
			(0.005)			(0.910)			(0.129)
Too noisy (1=yes)			-0.042			-0.338**			0.077
			(0.829)			(0.020)			(0.725)
Observations	13100	13100	13100	13100	13100	13100	13100	13100	13100
R-squared	0.081	0.083	0.086	0.041	0.046	0.073	0.050	0.051	0.054
Number of individuals	3882	3882	3882	3882	3882	3882	3882	3882	3882
Socio-Economic controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Movers excluded	YES	YES	YES	YES	YES	YES	YES	YES	YES

*** Significantly different from 0 at 1 percent level. ** Significantly different from 0 at 5 percent level. * Significantly different from 0 at 10 percent level.

Table 11: Effect of housing problems on different types of healthcare visits (full table in App. D.5)

A summary of all the significant relationships has been visualised in appendix D.6. Again, only the significant links are presented where green borders indicate a positive relation and red borders a negative one. Moreover, a dashed line indicates a significance level of 10 percent while solid lines point towards a more significant relation with p-values below 5 percent.

4.3. Effect of housing problems on WOZ-value: The value of renovation

There is clearly evidence that several housing conditions affect human health for owner-occupied housing which should incentivize owners to renovate and solve problems if needed. However, as mentioned before, the costs of renovation will be completely carried by the

owners. The intrinsic motivation of "better health" might not be a sufficient driver for renovation. Is there also an extrinsic motivator by, for example, a higher WOZ-value after solving problems? In order to test this, six regressions will be executed for the following housing types: (1) single family detached house, (2) single family corner house, (3) single family duplex house, (4) single family row house, (5) apartment and (6) other housing types not covered by the previous ones. This distinction is of importance due to the fact that housing type is a clear indicator of WOZ-value which should be controlled for. Table 12 reports that detached houses experience a 9.7 percent drop in WOZ-value when at least one problem is observed. This is significant at a 10 percent level. Moreover, duplex houses seem to decline in value even more, 11.4 percent, when a problem is reported. Lastly, a 11.3 percent reduction of the WOZ-value of apartments can be observed when problems occur. Solving housing problems seems to positively impact the WOZ-value for detached houses, duplex houses and apartments. This does not imply that renovating any other housing type will not increase the WOZ-value but an explanation is that housing problems might be more specifically related to the housing type itself in these cases. For instance, row houses are more noisy than detached houses by nature. Improving isolation will reduce the noise levels but might not impact WOZ-value directly.

	Log WOZ-Value (Single fam. detached)	Log WOZ-Value (Single fam. corner)	Log WOZ-Value (Single fam. duplex)	Log WOZ-Value (Single fam. row)	Log WOZ-Value (Apartment)	Log WOZ-Value (Other)
Housing problem (t-1)	-0.097*	-0.015	-0.114**	-0.031	-0.113**	0.074
	(0.080)	(0.705)	(0.016)	(0.411)	(0.012)	(0.508)
Observations	3410	2476	3230	4873	1999	1059
R-squared	0.284	0.316	0.270	0.197	0.375	0.378
Number of individuals	899	583	851	1054	520	164
Socio-Economic controls	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES

*** Significantly different from 0 at 1 percent level. ** Significantly different from 0 at 5 percent level. * Significantly different from 0 at 10 percent level.

Table 12: Effects of at least one housing problem on WOZ-value per type (full table in App. D.7)

The results section has thoroughly exposed which housing problems have an effect on health and in which way. Moreover, the extrinsic value of renovation has been estimated for all housing types. The implications of the results will be discussed in the next sections. Moreover, a theoretical framework will be proposed by which healthcare cost savings could be estimated.

5. Discussion, implications and conclusion

The previous sections have successfully sketched a detailed range of relationships between housing problems and health. The aim of this discussion will be to provide a practical interpretation of what these results could imply for the pressing healthcare costs in the Netherlands by evaluating relevant problems and taking into account the costs and benefits of renovation. A similar approach to this could be taken on a problem-specific level. Afterwards, the strategic considerations for the involved stakeholders will be investigated.

5.1. Healthcare cost savings

The following sections will first of all discuss what cost savings could be made by solving all housing problems regardless of type and investment needed. Cost savings will again be divided in (1) economic costs of hindrance and (2) direct healthcare costs of yearly healthcare visits.

5.1.1. Economic cost savings by decreasing hindrance

Table 7 provided evidence that hindrance increases by 11 percent on average if a house contains a problem. Moreover, table 3 indicated that 15 percent of all owner-occupied homes experience at least one problem. Combining these two findings tells us that renovating this problematic proportion of the buildings would decrease the total economic costs stemming from hindrance among Dutch owners by 1.65 percent (0.11 * 0.15). Whether this can be regarded as an investment worth the cost depends on the equation for renovation described in section 2.5.:

$$\Delta Health\ status + \Delta WOZvalue + \Delta Perceived\ social\ benefit > Renovation\ costs$$

In appendix A.2 it is stated that 28 percent of owners in problem-free houses experiences hindrance while this is 35 percent for houses with a problem. Principally, by renovating one's house the probability of experiencing hindrance declines by 7 percentage points, hence implying a positive $\Delta Health\ status$. According to table 12, renovation will also ensure a $\Delta WOZvalue$ of around 10 percent but only in the case of a detached house, a duplex house, or an apartment. The $\Delta Social\ benefit$ stems from both the 1.65 percent economic cost decrease mentioned earlier and an unknown value created by innovative and sustainable building that is subjective for each individual. This is however, beyond the scope of this paper. Whenever the accumulation of these three factors exceeds the $Renovation\ costs$, owners will be inclined to

renovate their home. Mind, however, that this line of reasoning is still very abstract and further research is necessary to expand this into a reliable perspective. Nevertheless, this is definitely a new and innovative way of thinking which could be a fundament for future analysis.

5.1.2. Healthcare cost savings by decreasing healthcare visits

The same reasoning can be done for the number of yearly healthcare visits. Being a direct driver of healthcare costs, this is the variable that revolves around the problem at hand; high healthcare costs. Table 7 presented that houses experiencing at least one problem entail no significantly higher healthcare usage. However, on the level of specific problems there are significant effects. For instance, both men and women visit a healthcare facility around 2.8 extra times per year when experiencing a dwelling that is *too dark*. Moving forward on this example, one could argue as follows. The dataset suggests that 2 percent of all owner-occupied houses is perceived as *too dark*. Solving all occurrences of lacking light will result in 0.056 (2.8 * 0.02) less healthcare visits per person on a yearly basis. Using the knowledge that an average owner visits a healthcare facility 3.61 times per year, this would imply a decrease of healthcare usage and its cost of 1.6 percent directly resulting from these renovations. Table 11 then enables us to more specifically decide from which type of healthcare facility the cost saving can be derived; in this case from psychological visits. Taking a similar approach as in the previous section could then again lead us to an equilibrium value for which owners will be indifferent about renovating. Again, it is extremely difficult to pinpoint some of the values within the proposed equation but the way of thinking remains valid.

5.2. Addressing housing problems in an innovative and sustainable way

Before coming to a conclusion, our research already allows us to answer the question *"*Do owner-occupied housing conditions affect health and its costs?" with a *yes*. Despite the fact that not all housing conditions taken into account for this analysis seem to impact health equally much and in a similar way, it would be beneficial, at least to some extent, to try and solve these issues in an attempt to reduce pressing healthcare costs in the Netherlands. This section will look at each housing problem individually and describe some innovative and preferably sustainable methods to reduce their problematic impact on human health in the order of importance claimed by our results. Dwelling size will be neglected due to the fact that it is extremely subjective and dependent of the amount of people living in a house. Moreover, it is

often not feasible to increase the size of someone's living area unless substantial investments are made with marginal effects as a result. The type of solution and its cost are directly related to the renovation costs referred to in the previous paragraphs.

With regards to comfort, proper lighting seems to be of utter importance for someone's health status. Smart and sustainable lighting solutions, like "Light Emitting Diodes" more formally known as LED, pose a sustainable solution to the problem. Combining LED with movement sensors that only switch the lights on when someone is in the room powered with electricity generated by solar panels would currently be the most preferred, though expensive, option for dwellings which are perceived as *too dark.*

Regarding hazardous problems, buildings suffering from a *leaking roof, damp walls or floors* or *rotten window frames or floors* could be facing similar underlying failures. Old-fashioned construction methods resulting in poor quality surfaces are mostly the cause of one or a combination of the aforementioned problems. Some innovative manual construction methods are the "Dew Point Method" and Glaser and Kieper diagrams. Without going into unnecessary much detail, these methods measure all kinds of external effects influencing the wall materials and consequently form a conclusion on which material, preferably sustainable, to use within each environment. Another innovative starting point for solving these issues is making use of a "MOIST" program. This is a computer program designed by the National Institute of Standards and Technology (NIST) which predicts heat and moisture transfer in a confined space. Contrary to manual methods, the MOIST program makes use of time-series data on weather conditions, temperature and building material durability. Thus, there are plenty of innovative solutions for hazardous problems for which sustainability has become a point of focus as well.

Similar to the problems above, isolation is a key component when dealing with *inadequate heating* and *noise.* Similar systems could therefore be implemented to optimize isolation. It is even possible to locate the most efficient spot for a ventilation system, thereby simultaneously solving the air quality problem. Regarding isolation, nowadays the most adequate and sustainable materials for isolation are perceived to be rigid Polystrene and Icynene which are both relatively cheap materials with a high insulation score (R-value) and great recycling potential. Besides installing proper isolation, the way in which heat is generated contributes to a sustainable approach towards an adequate indoor temperature. A heat pump is considered to be a relatively sustainable way of moving heat from one place to another by using labour. A fridge is a well-known and widely used application of a heat pump. Since a heat pump is still

driven by electricity, the source of this electricity is key for whether a heat pump is truly sustainable. Therefore, initiatives towards green energy make the usage of heat pumps as efficient temperature regulators more sustainable in general. A combination of healthy and sustainable housing renovations seems to be feasible and optimal in an attempt to improve human health and lower pressing healthcare costs.

5.3. Strategic considerations

In section 2.5., the concept of business models has already been introduced. Following from the results, the question arises: "Are there stakeholders involved that should change their business model based on the outcome of this research?" Besides the home-owners, there are several other key stakeholders involved which will be identified with the aid of figure 6. This figure has been proposed by Eden and Ackermann (1998) in an attempt to sketch, on the one hand, which stakeholders are interested in a specific outcome, scenario or trend and, on the other hand, which stakeholders have the power to impact the situation.

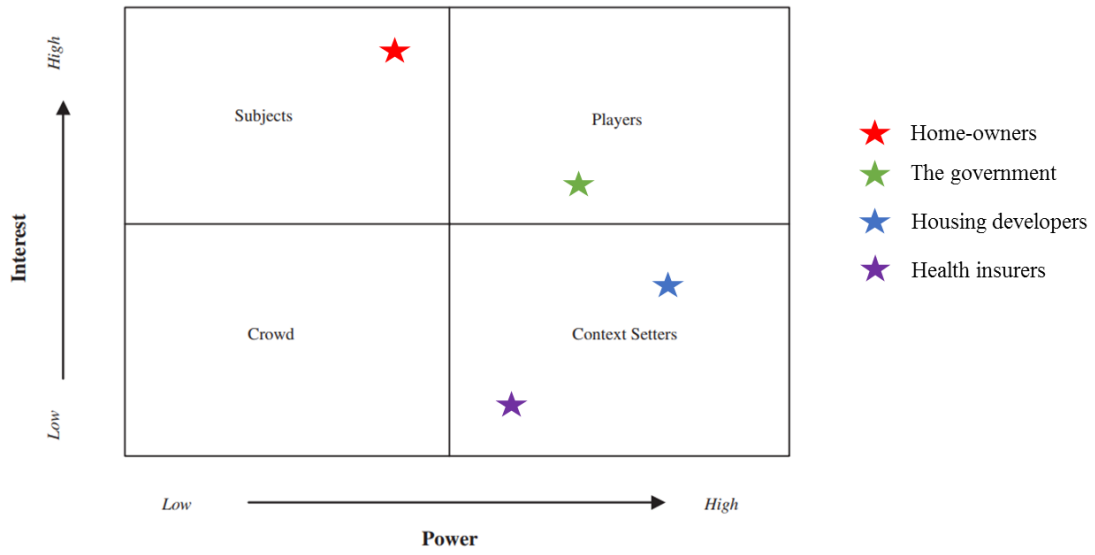

Figure 6: Stakeholder identification: Based on the Power and Interest grid (Eden & Ackermann, 1998)

The *crowd* is the group that has both little interest and little power regarding the question at hand. Therefore, this group will be disregarded for the convenience of our analysis. The *subjects* are the stakeholders that would benefit from a change but have very limited options to take control of the situation. In this case these stakeholders would arguably be the home-owners. Even though home-owners could renovate their house and ensure both a WOZ-value increase

and improved health resulting in lower healthcare costs, they are subjective to whether housing developers decide to offer healthy building solutions. Research already presented in previous sections, on whether this is the case, indicated that currently there are some healthy building solutions, such as radon control and usage of less damaging materials, but substantially more could and should be done by housing developers; their business model should be adapted. Considering their power is high and their interest seems to be on the lower side of the spectrum they can be regarded as *context setters* in the current situation. Furthermore, as can be concluded from the intensity of discussion in the parliament concerning healthcare costs, the government could be regarded as a stakeholder with high interest and high power, or a *player*. Their main focus lies on determining how they can effectively exert their inertial power and steer towards decreasing healthcare costs. The last stakeholders that seem to be of importance are health insurers. They play a major role in the allocation and distribution of healthcare expenses, when recalling figure 3. However, up until now they have not engaged themselves actively in housing quality making them *context setters*.

Following the line of reasoning introduced by Geels (2011), it seems that the concept of healthy buildings is still a "niche" while a combination of sustainability and profitability seem to determine the current "regime" in the "landscape" sketched by the roles each stakeholder plays at the moment. In order to enable home-owners to invest in healthy housing solutions and increase their power, housing developers should become more "interested" in providing these solutions by becoming a *player* in the field as well. Health insurers, a seemingly independent type of stakeholder, could incentivize housing developers by providing, for example, discounts to people living in homes built or renovated with healthy procedures. Similar to the WELL certificate, granting homes a "health-index" could signal to insurers that the residents will, in general, be less likely to declare healthcare costs. In turn, health insurers could grant discounts to inhabitants of healthy homes, incentivizing both home-owners and housing developers to invest in healthy building. Renovating "unhealthy" homes could under these circumstances be considered as a key selling point for housing developers. The government should promote this cooperation since it will result in their healthcare costs objective being reached more quickly. The arrows in figure 7 indicate how the landscape should shift to promote healthy building. Disruptive innovations could accelerate the transformation. Stakeholders should not solely shift their own business model, but the whole system has to adapt to ensure the knife will cut on both sides (Senge, Smith, Kruschwitz, Laur and Schley, 2008).

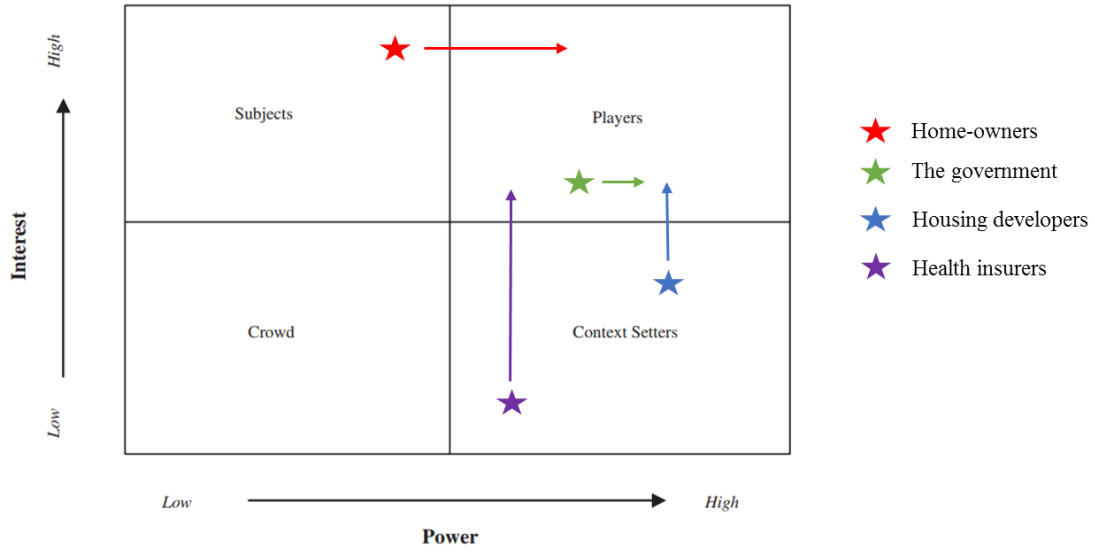

Figure 7: Stakeholder identification: Based on the Power and Interest grid (Eden & Ackermann, 1998)

Lastly, Appendix E.1 contains a framework introduced by Bocken et al. (2014) which describes eight archetypes that a business model can make use of. In terms of archetypes, housing developers nowadays are mainly present in the technological field while especially focusing on the maximization of material- and energy efficiency and substitution with renewables and natural processes. Housing developers should definitely keep up their pace in these sectors but based on this thesis they are suggested to divert to social and organizational practices as well. Especially, adopting a stewardship role by promoting health and well-being would hit the nail on its head in the battle against healthcare costs. For the three aspects of the business model approach this would mean that the value proposition should be shifted in terms of products and services while the value creation and delivery should be adapted in terms of partners and cooperation channels.

5.4. Concluding remarks

This study has explored whether inhabitants' health is affected by owner-occupied housing conditions. While this seems to be an evident question to answer, it has proven to be challenging in the past. Until now, there has not been much research done on the effect of indoor conditions on health in Western countries. Based on the LISS dataset consisting of more than 50,000 respondent/year observations between 2007 and 2017 it has been possible to provide evidence for some clear causal relationships between housing conditions and health.

The analyses show that houses with at least one problem, which is 15 percent of all owner-occupied homes, experience a significantly lower general health perception and happiness while facing an 11 percent increase of the probability for hindrance from disease. Simultaneously residents living in problematic houses tend to visit a healthcare facility 0.5 extra times on a yearly basis. Moreover, there is evidence for the fact that dwellings that are perceived as *too dark* lead to more psychological visits and a lower happiness score. This appears to be the case for both males and females. Causality, however, has been hard to consolidate for this specific problem. Furthermore, hazardous problems seem to be the major creators of poor health and hence drivers of healthcare costs, both directly and indirectly. Men seem to suffer the most from *leaks* and *inadequate heating* while women are more sensitive to *rot* and *mold*. Due to the limited amount of observations, it has been challenging to establish a clear pattern for age groups. There is, however, partial evidence of the fact that the elderly suffer more from poor housing conditions than younger people.

5.5. Limitations and implications for further research

It can be expected that research on this topic will become even more relevant when datasets, like LISS, succeed in aggregating representative data over longer time periods in order for trends to be evaluated. That being said, this research has not been able to overcome some inevitable complications raising several limitations that should be dealt with in further research. First of all, due to the fact that a respondent, on average, participated in the survey for only 4.29 waves we have only been able to execute OLS regressions. More beneficial would be to check for fixed and random effects based on a Hausmann-test. However, this has not been possible in this analysis due to the small amount of observations per person.

Furthermore, it remains a given fact that surveys are subjective. The seven measures for housing conditions represent a perception of an individual rather than commonly determined indicators for housing issues. This could be solved by sending experts to the houses to determine what the problems are and link those to the survey, which would be extremely expensive and time consuming.

A final limitation is that of reversed causality. We found clear indicators of the fact that people who perceive their home as *too dark* are in general less happy and visit a (psychological) healthcare facility substantially more often. It would be interesting to look at the fact whether the perception of darkness stems from the fact that residents are already depressed and therefore

would perceive a dwelling as *too dark* more easily than another person. However, further tests for reversed causality have proven that a lack of light is typical for row houses and apartments with 66 percent of all the occurrences appearing in those two dwelling types. Therefore, we have reason to believe the problem *too dark* is more related to dwelling type than to a respondent's mental well-being.

Future research can build on the findings and limitations of this thesis in an attempt to pinpoint more precisely how healthcare costs could be reduced. More objective measures for housing conditions should be taken into consideration. Moreover, the costs of renovation should be further investigated to be able to make more educated estimations of the trade-off that has been described in this thesis. One should always take into account innovative and sustainable solutions in an attempt to improve the health status in the Netherlands as a whole and decrease healthcare costs with it. Finally, methods to incentivize stakeholders, and especially health insurers, should be explored more thoroughly in order to change the system as it currently operates.

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6.1. Figures

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7. Appendix

Appendix A – General descriptives

	Too small	Too dark	Too cold	Leakage	Damp	Rot	Too noisy
Too small							
Too dark	5,9%						
Too cold	6,2%	7,0%					
Leakage	2,8%	3,0%	7,1%				
Damp	6,5%	4,0%	10,0%	8,2%			
Rot	4,3%	3,2%	11,5%	9,7%	12,7%		
Too noisy	12,3%	5,0%	8,6%	3,8%	9,4%	7,3%	

Appendix Table A.1: Cross-tabulation of specific problems

Appendix Table A.2: Effect of problems on the five health indicators by age and income quartiles and ownership

Panel A: General health status by house conditions for different age, income and tenancy status groups

	Respondent Age				Household Net Income (annual)				Ownership Status	
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	(Co-)Owner	(Sub-)Tenant
No problem	3.42	3.20	3.05	2.94	2.93	3.05	3.14	3.28	3.13	2.96
Problem	3.29	3.03	2.75	2.77	2.77	3.03	3.02	3.17	3.04	2.90

Panel B: Proportion of people reporting bad health status by dwelling condition for different age, income and tenancy status groups

	Respondent Age				Household Net Income (annual)				Ownership Status	
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	(Co-)Owner	(Sub-)Tenant
No problem	0.08	0.11	0.17	0.23	0.25	0.19	0.13	0.10	0.14	0.24
Problem	0.12	0.18	0.34	0.33	0.36	0.19	0.18	0.18	0.19	0.28

Panel C: Happiness by house conditions for different age, income and tenant status groups

	Respondent Age				Household Net Income (annual)				Ownership Status	
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	(Co-)Owner	(Sub-)Tenant
No problem	7.65	7.56	7.58	7.88	7.38	7.67	7.75	7.88	7.71	7.38
Problem	7.39	7.14	6.87	7.56	6.78	7.28	7.35	7.56	7.33	6.97

Panel D: Yearly visits to the doctor by house conditions for different age, income and tenancy status groups

	Respondent Age				Household Net Income (annual)				Ownership Status	
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	(Co-)Owner	(Sub-)Tenant
No problem	3.48	3.32	3.81	5.30	5.65	4.11	3.67	3.18	3.61	5.84
Problem	4.53	4.74	5.62	5.57	6.77	4.44	3.97	3.51	3.76	6.10

Panel E: Proportion of people reporting any hindrance by house conditions for different age, income and tenancy status groups

	Respondent Age				Household Net Income (annual)				Ownership Status	
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	(Co-)Owner	(Sub-)Tenant
No problem	0.28	0.26	0.31	0.37	0.41	0.32	0.27	0.22	0.28	0.42
Problem	0.34	0.40	0.50	0.49	0.55	0.36	0.36	0.32	0.35	0.49

Appendix B – Owner descriptives

Appendix table B.1: Owner descriptive statistics distinguishing between amount of problems

	In good condition (no problem)	Experiencing one type of problem	Experiencing multiple types of problems*
Monthly household income	3215.10	2838.89	2683.24
	(4388.52)	(2192.22)	(1484.37)
Age of respondent	54.91	49.36	47.57
	(14.03)	(13.49)	(12.76)
Number of rooms	4.82	4.51	4.21
	(1.36)	(1.40)	(1.34)
WOZ-value	315605.25	242596.92	205810.25
	(1114465.20)	(299920.61)	(139386.13)
Dwelling typology			
Single family home - Detached (1=yes)	0.22	0.11	0.10
Single family home - Corner lot (1=yes)	0.15	0.15	0.11
Single family home - Duplex house (1=yes)	0.20	0.14	0.08
Single family home - Row house (1=yes)	0.27	0.36	0.31
Apartment (1=yes)	0.10	0.17	0.26
Other (1=yes)	0.06	0.07	0.14
External environment			
Neighbour noise annoyance (1=yes)	0.11	0.34	0.57
Street noise annoyance (1=yes)	0.08	0.14	0.32
Stench, dust or dirt (1=yes)	0.04	0.08	0.15
Vandalism or crime (1=yes)	0.05	0.09	0.20
None of these (1=yes)	0.77	0.51	0.25
Household size	2.49	2.50	2.61
	(1.23)	(1.36)	(1.36)
Partner (1=yes)	0.83	0.78	0.80
Amount of children living at home	0.70	0.81	0.90
	(1.06)	(1.11)	(1.09)

*multiple problems contains occurence of 2 and 3 types of problems combined due to small sample with 3 problem types (n=51)

Appendix table B.2: Owner descriptive statistics distinguishing between three problem categories

	In good condition (no problem)	Comfort problems	Hazardous problems	Noise problems
Monthly household income	3215.10	3035.47	2753.82	2604.68
	(4388.52)	(1910.71)	(2239.67)	(1784.71)
Age of respondent	54.91	44.16	50.74	49.89
	(14.03)	(14.00)	(13.17)	(13.47)
Number of rooms	4.82	3.98	4.74	4.33
	(1.36)	(1.25)	(1.50)	(1.24)
WOZ-value	315605.25	203538.37	254266.00	228850.63
	(1114465.20)	(112616.30)	(206126.45)	(366227.49)
Dwelling typology				
Single family home - Detached (1=yes)	0.22	0.09	0.18	0.04
Single family home - Corner lot (1=yes)	0.15	0.10	0.15	0.15
Single family home - Duplex house (1=yes)	0.20	0.13	0.10	0.14
Single family home - Row house (1=yes)	0.27	0.36	0.30	0.40
Apartment (1=yes)	0.10	0.28	0.13	0.25
Other (1=yes)	0.06	0.04	0.14	0.03
External environment				
Neighbour noise annoyance (1=yes)	0.11	0.34	0.24	0.64
Street noise annoyance (1=yes)	0.08	0.19	0.18	0.23
Stench, dust or dirt (1=yes)	0.04	0.11	0.10	0.10
Vandalism or crime (1=yes)	0.05	0.13	0.14	0.12
None of these (1=yes)	0.77	0.50	0.56	0.24
Household size	2.49	2.69	2.52	2.39
	(1.23)	(1.41)	(1.37)	(1.30)
Partner (1=yes)	0.83	0.84	0.80	0.73
Amount of children living at home	0.70	0.95	0.82	0.75
	(1.06)	(1.18)	(1.12)	(1.02)

Appendix C – Regression results (all indicators)

	Bad Health (1=yes)	Bad Health (1=yes)	Health perception (1-5)	Health perception (1-5)	Happiness (0-10)	Happiness (0-10)	Healthcare visits	Healthcare visits	Hindrance (%)	Hindrance (%)
Housing problem (t-1) (1=yes)	0.057***	0.058***	-0.126***	-0.108***	-0.106**	-0.096*	0.530**	0.549**	0.088***	0.114***
	(0.001)	(0.003)	(0.000)	(0.005)	(0.028)	(0.082)	(0.015)	(0.036)	(0.000)	(0.000)
Number of rooms	0.008	0.010	-0.007	-0.044	-0.010	-0.019	0.108	0.121	0.011	0.001
	(0.466)	(0.419)	(0.723)	(0.076)	(0.739)	(0.601)	(0.441)	(0.477)	(0.415)	(0.954)
Log of WOZ-Value	0.007	0.009	-0.007	0.008	-0.113***	-0.117***	0.221	0.249	-0.005	-0.013
	(0.579)	(0.578)	(0.798)	(0.803)	(0.003)	(0.007)	(0.205)	(0.231)	(0.745)	(0.495)
Dwelling satisfaction (0-10)	-0.011*	-0.018**	0.035***	0.038**	0.210***	0.222***	0.099	0.073	0.008	0.000
	(0.098)	(0.030)	(0.007)	(0.017)	(0.000)	(0.000)	(0.255)	(0.498)	(0.338)	(0.974)
Vicinity satisfaction (0-10)	-0.012*	-0.011	0.056***	0.059***	0.162***	0.186***	-0.196**	-0.178*	-0.025***	-0.023**
	(0.051)	(0.139)	(0.000)	(0.000)	(0.000)	(0.000)	(0.012)	(0.065)	(0.001)	(0.011)
Vicinity problems										
Vicinity noise (neighbours) (1=yes)	0.046***	0.032*	-0.042	-0.012	-0.058	-0.058	0.145	-0.106	0.040*	0.035
	(0.005)	(0.099)	(0.194)	(0.742)	(0.220)	(0.288)	(0.500)	(0.681)	(0.054)	(0.154)
Vicinity noise (street) (1=yes)	0.017	0.017	0.020	0.025	-0.003	0.043	0.230	0.144	0.063***	0.040
	(0.373)	(0.447)	(0.597)	(0.556)	(0.963)	(0.489)	(0.361)	(0.623)	(0.009)	(0.142)
Vicinity pollution (1=yes)	0.086***	0.050	-0.141***	-0.106*	-0.003	0.072	0.594*	0.570	0.035	0.052
	(0.001)	(0.106)	(0.007)	(0.077)	(0.970)	(0.400)	(0.089)	(0.166)	(0.294)	(0.177)
Vicinity crime (1=yes)	0.043*	0.052*	0.015	0.043	0.078	0.127	0.482	0.762*	0.041	0.033
	(0.085)	(0.075)	(0.758)	(0.445)	(0.268)	(0.124)	(0.132)	(0.051)	(0.188)	(0.371)
Household size	-0.003	-0.023	0.020	0.070	-0.184**	-0.173	-0.514	-0.528	-0.008	-0.012
	(0.916)	(0.550)	(0.757)	(0.359)	(0.048)	(0.115)	(0.222)	(0.311)	(0.847)	(0.807)
Partner (1=yes)	-0.077***	-0.121***	0.219***	0.345***	0.293***	0.373***	-0.416	-0.313	-0.041	-0.084**
	(0.004)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.223)	(0.472)	(0.211)	(0.039)
Living together with partner (1=yes)	0.053	0.088**	-0.218***	-0.296***	0.425***	0.372***	0.016	-0.045	-0.019	0.045
	(0.131)	(0.045)	(0.002)	(0.001)	(0.000)	(0.003)	(0.972)	(0.939)	(0.670)	(0.417)
Married (1=yes)	-0.038*	-0.040	0.054	0.059	0.067	0.072	0.425	0.218	0.016	-0.009
	(0.075)	(0.125)	(0.194)	(0.245)	(0.278)	(0.324)	(0.127)	(0.532)	(0.560)	(0.784)
Number of children	-0.008	-0.011	-0.013	0.038	0.132*	0.160*	0.061	-0.109	-0.026	-0.014
	(0.756)	(0.724)	(0.794)	(0.517)	(0.068)	(0.058)	(0.851)	(0.785)	(0.406)	(0.705)
Age of respondent	0.003***	0.003***	-0.010***	-0.008***	0.001	0.003	0.014	0.012	0.002**	0.002**
	(0.000)	(0.001)	(0.000)	(0.000)	(0.672)	(0.264)	(0.114)	(0.289)	(0.032)	(0.031)
Log of monthly household income	-0.009	-0.004	0.035**	0.034**	0.059***	0.057**	-0.037	-0.009	-0.021**	-0.019*
	(0.206)	(0.608)	(0.017)	(0.036)	(0.006)	(0.016)	(0.699)	(0.939)	(0.025)	(0.068)
Individual is working (1=yes)	-0.075***	-0.080***	0.117***	0.131***	0.075*	0.076	-1.026***	-1.159***	-0.064***	-0.059***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.087)	(0.117)	(0.000)	(0.000)	(0.001)	(0.006)
Individual is studying (1=yes)	-0.085	0.008	-0.378	-0.547	-0.139	-0.359	1.006	-0.449	0.187	0.962**
	(0.676)	(0.981)	(0.340)	(0.422)	(0.810)	(0.713)	(0.703)	(0.923)	(0.464)	(0.028)
Individual has a higher education degree (1=yes)	-0.001	-0.015	0.071***	0.082***	0.122***	0.110***	-0.257	-0.249	-0.024	-0.035**
	(0.963)	(0.300)	(0.003)	(0.003)	(0.001)	(0.006)	(0.109)	(0.190)	(0.121)	(0.048)
Ratio household members per room	0.117	0.200*	-0.196	-0.604***	-0.032	-0.140	1.217	1.843	0.099	0.078
	(0.220)	(0.089)	(0.290)	(0.008)	(0.907)	(0.670)	(0.325)	(0.240)	(0.406)	(0.596)
Individual smoked ever (1=yes)	0.002	0.007	-0.057**	-0.065**	0.029	0.008	-0.095	-0.097	0.003	-0.018
	(0.890)	(0.645)	(0.026)	(0.028)	(0.436)	(0.845)	(0.577)	(0.631)	(0.874)	(0.335)
Individual smokes currently (1=yes)	0.030*	0.016	-0.066**	-0.017	-0.165***	-0.165***	-0.798***	-1.094***	0.015	0.019
	(0.060)	(0.391)	(0.033)	(0.634)	(0.000)	(0.001)	(0.000)	(0.000)	(0.462)	(0.394)
Individual is frequent drinker (1=yes)	-0.042***	-0.039***	0.069***	0.058**	-0.096***	-0.126***	-0.249	-0.271	-0.027*	-0.011
	(0.001)	(0.005)	(0.003)	(0.032)	(0.006)	(0.001)	(0.113)	(0.142)	(0.070)	(0.536)
Individual practices sports (1=yes)	-0.057***	-0.045***	0.133***	0.120***	0.067**	0.072**	-0.261*	-0.309*	-0.066***	-0.070***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.042)	(0.049)	(0.080)	(0.074)	(0.000)	(0.000)
Body-Mass-Index	0.008***	0.006***	-0.021***	-0.020***	-0.004	-0.006	0.100***	0.103***	0.009***	0.008***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.378)	(0.186)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	17047	13152	17047	13152	14070	10841	17047	13152	17047	13152
R-squared	0.080	0.078	0.127	0.125	0.201	0.212	0.062	0.071	0.064	0.070
Number of individuals	4678	3882	4678	3882	3965	3055	4678	3882	4678	3882
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
Movers excluded	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

*** Significantly different from 0 at 1 percent level. ** Significantly different from 0 at 5 percent level. * Significantly different from 0 at 10 percent level.

Appendix table C.1: Effect of having at least one housing problem on health indicators (full version of table 4)

	Bad Health (1=yes)	Bad Health (1=yes)	Health perception (1-5)	Health perception (1-5)	Happiness (0-10)	Happiness (0-10)	Healthcare visits	Healthcare visits	Hindrance (%)	Hindrance (%)
Housing problem category (t-1)										
Comfort problems (1=yes)	0.040	0.064*	-0.088	-0.061	0.005	-0.078	0.643*	1.065**	0.055	0.094**
	(0.149)	(0.063)	(0.100)	(0.368)	(0.951)	(0.424)	(0.072)	(0.022)	(0.109)	(0.030)
Hazardous problems (1=yes)	0.084***	0.096***	-0.184***	-0.169***	-0.110	-0.019	0.635**	0.849**	0.078***	0.121***
	(0.000)	(0.001)	(0.000)	(0.002)	(0.107)	(0.806)	(0.038)	(0.022)	(0.008)	(0.000)
Noise problems (1=yes)	0.010	0.004	-0.008	-0.024	-0.062	-0.046	0.058	-0.253	0.057*	0.049
	(0.666)	(0.881)	(0.858)	(0.655)	(0.361)	(0.557)	(0.851)	(0.489)	(0.054)	(0.149)
Number of rooms	0.008	0.009	-0.008	-0.043*	-0.012	-0.018	0.101	0.102	0.010	-0.001
	(0.467)	(0.480)	(0.715)	(0.084)	(0.707)	(0.620)	(0.473)	(0.550)	(0.446)	(0.953)
Log of WOZ-Value	0.006	0.008	-0.004	0.009	-0.111***	-0.116***	0.213	0.241	-0.006	-0.014
	(0.637)	(0.595)	(0.886)	(0.772)	(0.004)	(0.008)	(0.222)	(0.248)	(0.713)	(0.473)
Dwelling satisfaction (0-10)	-0.010	-0.016*	0.037**	0.036**	0.212***	0.224***	0.111	0.098	0.008	0.001
	(0.130)	(0.055)	(0.010)	(0.024)	(0.000)	(0.000)	(0.202)	(0.368)	(0.337)	(0.937)
Vicinity satisfaction (0-10)	-0.012**	-0.012	0.057***	0.060***	0.162***	0.186***	-0.205***	-0.195**	-0.026***	-0.024***
	(0.039)	(0.103)	(0.000)	(0.000)	(0.000)	(0.000)	(0.009)	(0.044)	(0.001)	(0.009)
Vicinity problems										
Vicinity noise (neighbours) (1=yes)	0.052***	0.038*	-0.057*	-0.024	-0.065	-0.063	0.198	-0.016	0.042**	0.041*
	(0.002)	(0.052)	(0.079)	(0.535)	(0.182)	(0.261)	(0.365)	(0.950)	(0.046)	(0.097)
Vicinity noise (street) (1=yes)	0.014	0.012	0.028	0.031	-0.001	0.044	0.188	0.073	0.060**	0.035
	(0.486)	(0.602)	(0.461)	(0.467)	(0.982)	(0.481)	(0.457)	(0.805)	(0.014)	(0.212)
Vicinity pollution (1=yes)	0.086***	0.049	-0.141***	-0.106*	-0.006	0.072	0.592*	0.554	0.036	0.051
	(0.001)	(0.113)	(0.007)	(0.078)	(0.943)	(0.404)	(0.090)	(0.178)	(0.291)	(0.187)
Vicinity crime (1=yes)	0.038	0.049*	0.024	0.050	0.083	0.125	0.456	0.744*	0.037	0.029
	(0.122)	(0.095)	(0.620)	(0.382)	(0.240)	(0.130)	(0.156)	(0.056)	(0.227)	(0.427)
Household size	-0.002	-0.019	0.018	0.067	-0.177*	-0.174	-0.473	-0.468	-0.006	-0.007
	(0.946)	(0.623)	(0.781)	(0.379)	(0.057)	(0.115)	(0.263)	(0.371)	(0.886)	(0.889)
Partner (1=yes)	-0.079***	-0.123***	0.225***	0.344***	0.295***	0.374***	-0.436	-0.349	-0.043	-0.06**
	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.202)	(0.423)	(0.196)	(0.036)
Living together with partner (1=yes)	0.055	0.087**	-0.220***	-0.292***	0.424***	0.371***	0.015	-0.038	-0.019	0.043
	(0.124)	(0.047)	(0.001)	(0.001)	(0.000)	(0.003)	(0.974)	(0.948)	(0.662)	(0.432)
Married (1=yes)	-0.039*	-0.039	0.056	0.059	0.067	0.074	0.426	0.227	0.016	-0.008
	(0.071)	(0.131)	(0.183)	(0.249)	(0.273)	(0.313)	(0.127)	(0.516)	(0.549)	(0.796)
Number of children	-0.009	-0.013	-0.012	0.040	0.130*	0.159*	0.044	-0.126	-0.027	-0.017
	(0.732)	(0.674)	(0.813)	(0.497)	(0.073)	(0.061)	(0.893)	(0.752)	(0.392)	(0.660)
Age of respondent	0.003***	0.003***	-0.010***	-0.008***	0.001	0.003	0.014	0.012	0.002**	0.002**
	(0.000)	(0.001)	(0.000)	(0.000)	(0.623)	(0.256)	(0.102)	(0.259)	(0.034)	(0.033)
Log of monthly household income	-0.010	-0.005	0.036**	0.035**	0.059***	0.057***	-0.043	-0.019	-0.021**	-0.020*
	(0.189)	(0.562)	(0.014)	(0.033)	(0.006)	(0.016)	(0.659)	(0.865)	(0.024)	(0.061)
Individual is working (1=yes)	-0.075***	-0.078***	0.115***	0.130***	0.076*	0.077	-1.014***	-1.124***	-0.064***	-0.057***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.083)	(0.117)	(0.000)	(0.000)	(0.001)	(0.008)
Individual is studying (1=yes)	-0.084	0.013	-0.380	-0.553	-0.132	-0.359	1.041	-0.395	0.186	0.965**
	(0.680)	(0.971)	(0.337)	(0.416)	(0.818)	(0.713)	(0.694)	(0.933)	(0.464)	(0.028)
Individual has a higher education degree (1=yes)	0.000	-0.015	0.071***	0.081***	0.120***	0.109***	-0.262	-0.258	-0.023	-0.035*
	(0.969)	(0.294)	(0.003)	(0.003)	(0.001)	(0.007)	(0.102)	(0.173)	(0.137)	(0.051)
Ratio household members per room	0.116	0.185	-0.196	-0.597**	-0.057	-0.127	1.082	1.560	0.092	0.057
	(0.228)	(0.118)	(0.295)	(0.010)	(0.834)	(0.703)	(0.385)	(0.322)	(0.446)	(0.701)
Individual smoked ever (1=yes)	0.002	0.007	-0.057**	-0.065**	0.029	0.008	-0.097	-0.096	0.002	-0.018
	(0.887)	(0.646)	(0.026)	(0.027)	(0.448)	(0.854)	(0.569)	(0.634)	(0.887)	(0.334)
Individual smokes currently (1=yes)	0.030*	0.015	-0.065**	-0.017	-0.165***	-0.165***	-0.799***	-1.107***	0.015	0.019
	(0.062)	(0.401)	(0.035)	(0.629)	(0.000)	(0.001)	(0.000)	(0.000)	(0.443)	(0.394)
Individual is frequent drinker (1=yes)	-0.042***	-0.039***	0.069***	0.057**	-0.097***	-0.127***	-0.246	-0.267	-0.027*	-0.010
	(0.001)	(0.005)	(0.003)	(0.033)	(0.005)	(0.001)	(0.116)	(0.147)	(0.077)	(0.561)
Individual practices sports (1=yes)	-0.058***	-0.046***	0.134***	0.121***	0.068**	0.073**	-0.262*	-0.310*	-0.067***	-0.070***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.039)	(0.048)	(0.078)	(0.074)	(0.000)	(0.000)
Body-Mass-Index	0.008***	0.006***	-0.021***	-0.020***	-0.003	-0.006	0.100***	0.102***	0.009***	0.008***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.403)	(0.192)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	17047	13152	17047	13152	14070	10841	17047	13152	17047	13152
R-squared	0.081	0.080	0.129	0.126	0.201	0.211	0.063	0.062	0.064	0.070
Number of individuals	4678	3882	4678	3882	3965	3055	4678	3882	4678	3882
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
Movers excluded	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

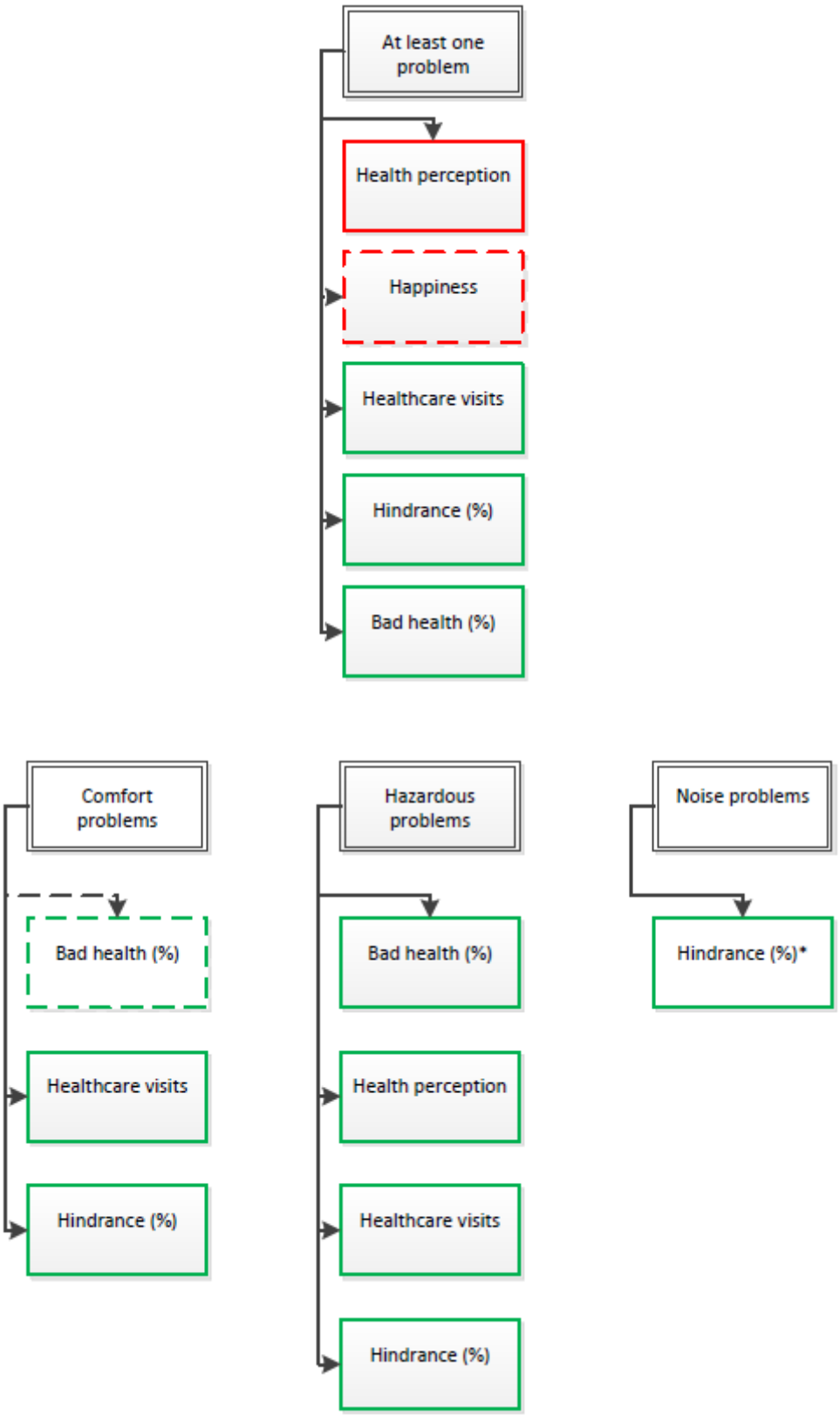
*** Significantly different from 0 at 1 percent level. ** Significantly different from 0 at 5 percent level. * Significantly different from 0 at 10 percent level.

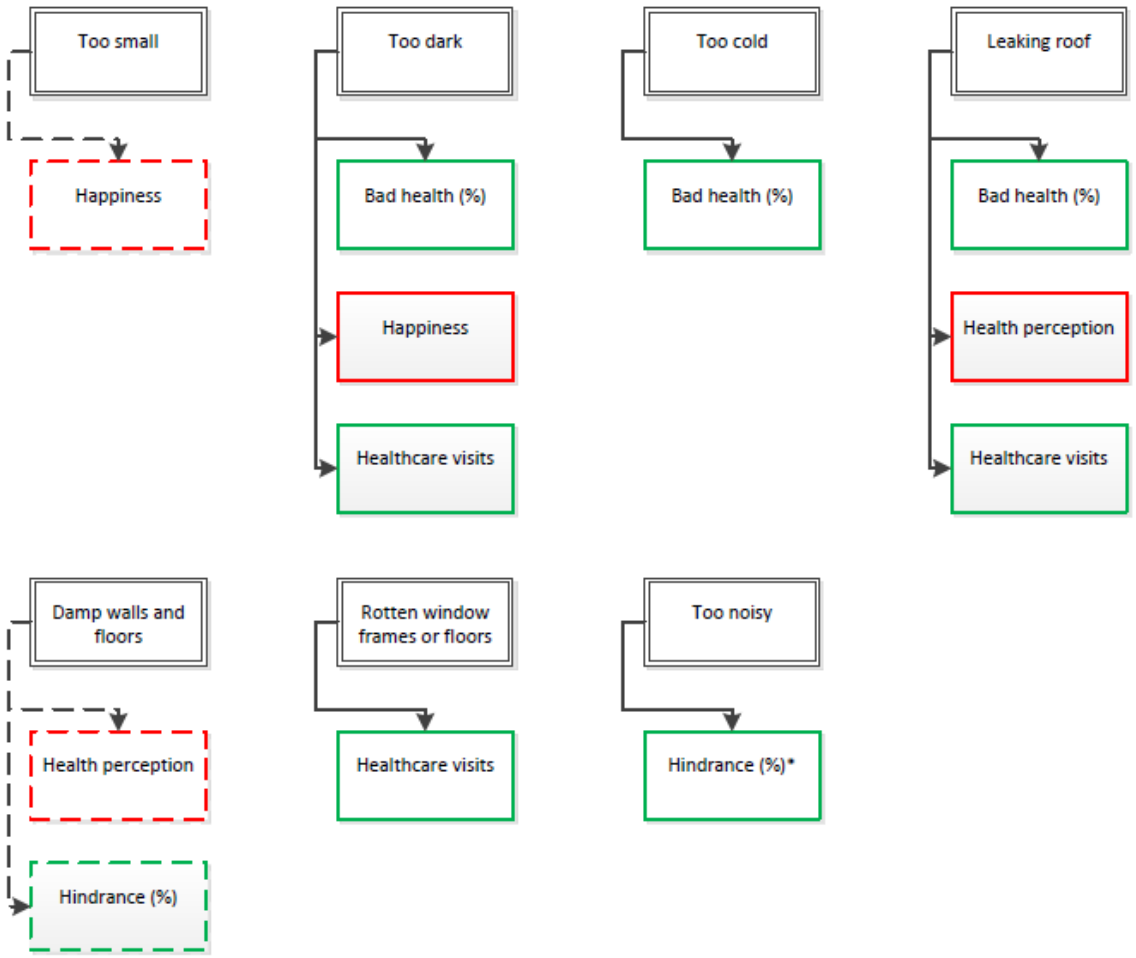
Appendix table C.2: Effect of different housing problem categories on health indicators (full version of table 5)

	Bad Health (1=yes)	Bad Health (1=yes)	Health perception (1-5)	Health perception (1-5)	Happiness (0-10)	Happiness (0-10)	Healthcare visits	Healthcare visits	Hindrance (%)	Hindrance (%)
Specific dwelling problems (t-1)										
Too small (1=yes)	0.019	0.052	-0.077	-0.079	0.171*	0.120	-0.047	-0.088	0.031	0.083
	(0.546)	(0.213)	(0.211)	(0.331)	(0.063)	(0.304)	(0.910)	(0.873)	(0.437)	(0.111)
Too dark (1=yes)	0.107**	0.090	-0.139	-0.055	-0.442***	-0.544***	1.89***	3.122***	0.092	0.103
	(0.024)	(0.116)	(0.132)	(0.617)	-0.001	(0.001)	(0.002)	(0.000)	(0.121)	(0.150)
Too cold (1=yes)	0.104**	0.153***	-0.015	0.044	0.137	0.195	0.423	0.208	0.105*	0.104
	(0.017)	(0.003)	(0.859)	(0.657)	(0.276)	(0.173)	(0.450)	(0.758)	(0.052)	(0.104)
Leaking roof (1=yes)	0.054	0.137**	-0.173*	-0.284**	-0.126	-0.122	1.415**	2.128***	0.078	0.078
	(0.247)	(0.018)	(0.058)	(0.012)	(0.352)	(0.461)	(0.020)	(0.006)	(0.183)	(0.286)
Damp walls and floors (1=yes)	0.025	0.025	-0.134*	-0.170*	-0.057	0.014	-0.360	-0.072	0.033	0.104*
	(0.507)	(0.583)	(0.069)	(0.053)	(0.604)	(0.913)	(0.465)	(0.904)	(0.494)	(0.065)
Rotten window frames or floors (1=yes)	0.065*	0.011	-0.212***	-0.131	-0.163	-0.029	1.284***	1.466**	0.069	0.091
	(0.087)	(0.814)	(0.004)	(0.136)	(0.139)	(0.823)	(0.009)	(0.015)	(0.144)	(0.107)
Too noisy (1=yes)	0.007	0.000	0.000	-0.019	-0.058	-0.054	0.002	-0.305	0.052*	0.047
	(0.781)	(0.994)	(1.000)	(0.718)	(0.397)	(0.484)	(0.996)	(0.404)	(0.078)	(0.170)
Number of rooms	0.008	0.008	-0.008	-0.042*	-0.018	-0.022	0.123	0.112	0.011	-0.001
	(0.436)	(0.536)	(0.712)	(0.093)	(0.556)	(0.536)	(0.382)	(0.511)	(0.423)	(0.930)
Log of WOZ-Value	0.006	0.009	-0.002	0.009	-0.105***	-0.111**	0.202	0.219	-0.007	-0.014
	(0.662)	(0.564)	(0.929)	(0.766)	(0.006)	(0.012)	(0.248)	(0.292)	(0.696)	(0.459)
Dwelling satisfaction (0-10)	-0.010	-0.015*	0.034**	0.035**	0.217***	0.229***	0.106	0.100	0.009	0.001
	(0.134)	(0.068)	(0.010)	(0.027)	(0.000)	(0.000)	(0.225)	(0.356)	(0.313)	(0.900)
Vicinity satisfaction (0-10)	-0.012**	-0.012*	0.057***	0.061***	0.159***	0.184***	-0.199**	-0.187*	-0.026***	-0.024**
	(0.041)	(0.095)	(0.000)	(0.000)	(0.000)	(0.000)	(0.011)	(0.053)	(0.001)	(0.010)
Vicinity problems										
Vicinity noise (neighbours) (1=yes)	0.053***	0.039**	-0.061*	-0.027	-0.070	-0.064	0.223	0.020	0.044**	0.042*
	(0.002)	(0.048)	(0.064)	(0.478)	(0.149)	(0.253)	(0.308)	(0.939)	(0.039)	(0.093)
Vicinity noise (street) (1=yes)	0.013	0.011	0.032	0.034	-0.001	0.037	0.180	0.093	0.058**	0.034
	(0.521)	(0.619)	(0.402)	(0.423)	(0.987)	(0.556)	(0.477)	(0.751)	(0.017)	(0.222)
Vicinity pollution (1=yes)	0.087***	0.048	-0.136***	-0.097	0.009	0.090	0.538	0.440	0.036	0.053
	(0.001)	(0.122)	(0.009)	(0.109)	(0.904)	(0.299)	(0.124)	(0.285)	(0.281)	(0.171)
Vicinity crime (1=yes)	0.034	0.042	0.029	0.056	0.091	0.123	0.366	0.678*	0.031	0.025
	(0.173)	(0.153)	(0.552)	(0.330)	(0.200)	(0.135)	(0.255)	(0.082)	(0.311)	(0.493)
Household size	-0.004	-0.014	0.019	0.062	-0.158*	-0.163	-0.519	-0.466	-0.007	-0.007
	(0.914)	(0.728)	(0.768)	(0.417)	(0.090)	(0.139)	(0.220)	(0.372)	(0.868)	(0.882)
Partner (1=yes)	-0.079***	-0.121***	0.228***	0.347***	0.291***	0.377***	-0.471	-0.383	-0.044	-0.086**
	(0.003)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.168)	(0.379)	(0.183)	(0.037)
Living together with partner (1=yes)	0.055	0.086*	-0.224***	-0.297***	0.423***	0.374***	0.037	-0.065	-0.018	0.045
	(0.122)	(0.051)	(0.001)	(0.001)	(0.000)	(0.003)	(0.936)	(0.911)	(0.689)	(0.419)
Married (1=yes)	-0.038*	-0.042	0.056	0.062	0.069	0.073	0.430	0.240	0.016	-0.010
	(0.074)	(0.109)	(0.183)	(0.222)	(0.263)	(0.318)	(0.123)	(0.491)	(0.555)	(0.770)
Number of children	-0.008	-0.017	-0.013	0.044	0.120*	0.152*	0.044	-0.145	-0.027	-0.016
	(0.741)	(0.578)	(0.795)	(0.452)	(0.097)	(0.074)	(0.893)	(0.716)	(0.385)	(0.675)
Age of respondent	0.003***	0.003**	-0.010***	-0.008***	0.001	0.003	0.013	0.011	0.002**	0.002**
	(0.000)	(0.002)	(0.000)	(0.000)	(0.586)	(0.260)	(0.150)	(0.333)	(0.042)	(0.034)
Log of monthly household income	-0.010	-0.005	0.036**	0.035**	0.060***	0.058**	-0.046	-0.023	-0.021**	-0.020*
	(0.177)	(0.534)	(0.014)	(0.031)	(0.005)	(0.015)	(0.637)	(0.839)	(0.023)	(0.062)
Individual is working (1=yes)	-0.077***	-0.079***	0.116***	0.126***	0.086*	0.087*	-1.061***	-1.178***	-0.065***	-0.057***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.050)	(0.075)	(0.000)	(0.000)	(0.001)	(0.009)
Individual is studying (1=yes)	-0.089	0.010	-0.379	-0.557	-0.113	-0.351	0.941	-0.455	0.182	0.966**
	(0.664)	(0.978)	(0.338)	(0.413)	(0.845)	(0.719)	(0.721)	(0.922)	(0.474)	(0.028)
Individual has a higher education degree (1=yes)	0.001	-0.015	0.069***	0.081***	0.116***	0.108***	-0.240	-0.250	-0.022	-0.034*
	(0.959)	(0.300)	(0.004)	(0.003)	(0.001)	(0.007)	(0.135)	(0.186)	(0.159)	(0.057)
Ratio household members per room	0.123	0.171	-0.202	-0.586**	-0.134	-0.176	1.391	1.748	0.100	0.057
	(0.201)	(0.150)	(0.282)	(0.011)	(0.626)	(0.596)	(0.265)	(0.267)	(0.404)	(0.702)
Individual smoked ever (1=yes)	0.003	0.008	-0.058**	-0.064**	0.024	0.001	-0.079	-0.066	0.003	-0.018
	(0.841)	(0.604)	(0.024)	(0.030)	(0.528)	(0.978)	(0.644)	(0.743)	(0.854)	(0.339)
Individual smokes currently (1=yes)	0.030*	0.017	-0.064**	-0.015	-0.160***	-0.160***	-0.816***	-1.120***	0.016	0.019
	(0.061)	(0.341)	(0.038)	(0.674)	(0.000)	(0.002)	(0.000)	(0.000)	(0.436)	(0.391)
Individual is frequent drinker (1=yes)	-0.041***	-0.038***	0.068***	0.055**	-0.097***	-0.124***	-0.228	-0.261	-0.026*	-0.009
	(0.001)	(0.006)	(0.004)	(0.043)	(0.005)	(0.001)	(0.145)	(0.156)	(0.087)	(0.586)
Individual practices sports (1=yes)	-0.057***	-0.045***	0.132***	0.121***	0.065**	0.071*	-0.2467*	-0.294*	-0.066***	-0.070***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.048)	(0.052)	(0.097)	(0.088)	(0.000)	(0.000)
Body-Mass-Index	0.008***	0.006***	-0.022***	-0.020***	-0.004	-0.006	0.101***	0.103***	0.008***	0.008***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.344)	(0.179)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	17047	13152	17047	13152	14070	10841	17047	13152	17047	13152
R-squared	0.083	0.083	0.130	0.127	0.205	0.215	0.067	0.080	0.065	0.070
Number of individuals	4678	3882	4678	3882	3965	3055	4678	3882	4678	3882
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
Movers excluded	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES

*** Significantly different from 0 at 1 percent level. ** Significantly different from 0 at 5 percent level. * Significantly different from 0 at 10 percent level.

Appendix table C.3: Effect of specific housing problems on health indicators (full version of table 6)


At least one problem
Health perception
Happiness
Healthcare visits
Hindrance (%)
Bad health (%)
Comfort problems
Bad health (%)
Healthcare visits
Hindrance (%)
Hazardous problems
Bad health (%)
Health perception
Healthcare visits
Hindrance (%)
Noise problems
Hindrance (%)*



**Noise problems only significant when excluding controls for neighbour- and street noise*

Appendix figure C.4: Visual summary of all significant relations involving all indicators

Appendix D – Regression results (cost indicators)

	Hindrance (%) (Male)	Hindrance (%) (Female)	Hindrance (%) (Male)	Hindrance (%) (Female)	Hindrance (%) (Male)	Hindrance (%) (Female)
Housing problem (t-1)	0.106***	0.114***				
	(0.001)	(0.003)				
Housing problem category (t-1)						
Comfort problems (1=yes)			0.183***	0.007		
			(0.001)	(0.926)		
Hazardous problems (1=yes)			0.090**	0.131**		
			(0.047)	(0.018)		
Noise problems (1=yes)			0.033	0.070		
			(0.470)	(0.186)		
Specific dwelling problems (t-1)						
Too small (1=yes)					0.124*	0.107
					(0.064)	(0.209)
Too dark (1=yes)					0.247***	-0.128
					(0.008)	(0.261)
Too cold (1=yes)					0.167**	-0.005
					(0.030)	(0.968)
Leaking roof (1=yes)					0.004	0.131
					(0.968)	(0.275)
Damp walls and floors (1=yes)					0.060	0.106
					(0.461)	(0.189)
Rotten window frames or floors (1=yes)					0.036	0.178*
					(0.618)	(0.058)
Too noisy (1=yes)					0.031	0.064
					(0.501)	(0.231)
Number of rooms	0.017	0.002	0.014	0.000	0.016	0.001
	(0.397)	(0.937)	(0.472)	(0.997)	(0.429)	(0.980)
Log of WOZ-Value	-0.018	-0.013	-0.019	-0.016	-0.021	-0.016
	(0.468)	(0.668)	(0.443)	(0.615)	(0.398)	(0.604)
Dwelling satisfaction (0-10)	-0.019	0.024	-0.016	0.024	-0.015	0.028
	(0.145)	(0.158)	(0.200)	(0.163)	(0.236)	(0.106)
Vicinity satisfaction (0-10)	-0.005	-0.051***	-0.006	-0.052***	-0.006	-0.053***
	(0.694)	(0.001)	(0.605)	(0.001)	(0.638)	(0.000)
Vicinity problems						
Vicinity noise (neighbours) (1=yes)	0.049	0.011	0.054*	0.018	0.055*	0.019
	(0.115)	(0.781)	(0.085)	(0.665)	(0.083)	(0.648)
Vicinity noise (street) (1=yes)	0.100***	-0.064	0.094***	-0.062	0.099***	-0.071
	(0.004)	(0.162)	(0.006)	(0.182)	(0.004)	(0.130)
Vicinity pollution (1=yes)	0.017	0.043	0.012	0.048	0.021	0.056
	(0.745)	(0.471)	(0.815)	(0.421)	(0.681)	(0.352)
Vicinity crime (1=yes)	-0.017	0.108*	-0.020	0.102*	-0.027	0.089
	(0.720)	(0.067)	(0.668)	(0.087)	(0.558)	(0.142)
Household size	-0.071	0.067	-0.064	0.073	-0.073	0.073
	(0.248)	(0.416)	(0.298)	(0.375)	(0.240)	(0.375)

Partner (1=yes)	-0.075	-0.024	-0.077	-0.009	-0.070	-0.014
	(0.150)	(0.724)	(0.141)	(0.897)	(0.184)	(0.840)
Living together with partner (1=yes)	0.049	-0.052	0.044	-0.071	0.044	-0.064
	(0.477)	(0.580)	(0.527)	(0.450)	(0.523)	(0.494)
Married (1=yes)	0.031	-0.021	0.037	-0.018	0.033	-0.021
	(0.448)	(0.708)	(0.369)	(0.742)	(0.428)	(0.710)
Number of children	0.033	-0.105*	0.030	-0.107*	0.036	-0.110*
	(0.501)	(0.082)	(0.534)	(0.077)	(0.454)	(0.072)
Age of respondent	0.005***	0.001	0.005***	0.000	0.005***	0.000
	(0.000)	(0.747)	(0.000)	(0.797)	(0.000)	(0.765)
Log of monthly household income	-0.023*	-0.015	-0.024*	-0.015	-0.024*	-0.014
	(0.092)	(0.376)	(0.077)	(0.364)	(0.078)	(0.416)
Individual is working (1=yes)	0.019	-0.131***	0.023	-0.132***	0.018	-0.126***
	(0.545)	(0.000)	(0.447)	(0.000)	(0.565)	(0.000)
Individual has a higher education degree (1=ye	-0.059***	0.049	-0.060***	0.049	-0.059***	0.052
	(0.008)	(0.130)	(0.006)	(0.131)	(0.007)	(0.114)
Ratio household members per room	0.220	-0.008	0.182	-0.025	0.209	-0.020
	(0.240)	(0.976)	(0.331)	(0.920)	(0.268)	(0.937)
Individual smoked ever (1=yes)	-0.017	-0.015	-0.017	-0.015	-0.015	-0.018
	(0.503)	(0.625)	(0.509)	(0.604)	(0.565)	(0.547)
Individual smokes currently (1=yes)	0.014	0.031	0.011	0.033	0.013	0.033
	(0.606)	(0.439)	(0.694)	(0.416)	(0.643)	(0.411)
Individual is frequent drinker (1=yes)	0.006	-0.010	0.008	-0.009	0.009	-0.005
	(0.786)	(0.745)	(0.710)	(0.767)	(0.689)	(0.875)
Individual practices sports (1=yes)	-0.068***	-0.080***	-0.069***	-0.080***	-0.069***	-0.080***
	(0.001)	(0.003)	(0.001)	(0.003)	(0.001)	(0.003)
Body-Mass-Index	0.013***	0.006***	0.013***	0.006***	0.013***	0.006***
	(0.000)	(0.025)	(0.000)	(0.032)	(0.000)	(0.039)
Observations	6583	6569	6583	6569	6583	6569
R-squared	0.082	0.093	0.086	0.092	0.087	0.096
Number of individuals	1943	1939	1943	1939	1943	1939
Socio-Economic controls	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES
Movers excluded	YES	YES	YES	YES	YES	YES

*** Significantly different from 0 at 1 percent level. ** Significantly different from 0 at 5 percent level.

* Significantly different from 0 at 10 percent level.

Appendix table D.1: Effect of housing problems on hindrance, male vs. female (full version of table 7)

	Healthcare visits (Male)	Healthcare visits (Female)	Healthcare visits (Male)	Healthcare visits (Female)	Healthcare visits (Male)	Healthcare visits (Female)
Housing problem (t-1)	0.411	0.467				
	(0.247)	(0.226)				
Housing problem category (t-1)						
Comfort problems (1=yes)			1.190*	0.840		
			(0.055)	(0.235)		
Hazardous problems (1=yes)			1.079**	0.268		
			(0.030)	(0.628)		
Noise problems (1=yes)			-0.427	-0.319		
			(0.399)	(0.549)		
Specific dwelling problems (t-1)						
Too small (1=yes)					0.282	-0.320
					(0.701)	(0.707)
Too dark (1=yes)					2.815***	2.779**
					(0.007)	(0.014)
Too cold (1=yes)					0.390	-0.220
					(0.643)	(0.852)
Leaking roof (1=yes)					3.320***	0.566
					(0.002)	(0.636)
Damp walls and floors (1=yes)					-0.127	-0.329
					(0.887)	(0.685)
Rotten window frames or floors (1=yes)					0.901	2.062**
					(0.252)	(0.028)
Too noisy (1=yes)					-0.562	-0.336
					(0.267)	(0.528)
Number of rooms	0.006	0.495*	-0.017	0.479*	-0.036	0.511*
	(0.977)	(0.087)	(0.937)	(0.098)	(0.869)	(0.077)
Log of WOZ-Value	0.535*	-0.359	0.533*	-0.370	0.514*	-0.382
	(0.054)	(0.254)	(0.055)	(0.241)	(0.064)	(0.225)
Dwelling satisfaction (0-10)	-0.261*	0.390**	-0.220	0.394**	-0.188	0.359**
	(0.065)	(0.023)	(0.120)	(0.023)	(0.183)	(0.039)
Vicinity satisfaction (0-10)	0.012	-0.428***	-0.006	-0.447***	-0.026	-0.404***
	(0.928)	(0.004)	(0.960)	(0.003)	(0.837)	(0.007)
Vicinity problems						
Vicinity noise (neighbours) (1=yes)	-0.440	0.397	-0.356	0.521	-0.292	0.532
	(0.198)	(0.317)	(0.303)	(0.203)	(0.398)	(0.193)
Vicinity noise (street) (1=yes)	0.400	-0.530	0.333	-0.599	0.265	-0.486
	(0.293)	(0.248)	(0.381)	(0.197)	(0.486)	(0.301)
Vicinity pollution (1=yes)	0.465	0.167	0.412	0.147	0.184	0.095
	(0.414)	(0.779)	(0.469)	(0.805)	(0.749)	(0.873)
Vicinity crime (1=yes)	0.687	1.219**	0.683	1.245**	0.604	1.227**
	(0.182)	(0.040)	(0.184)	(0.037)	(0.241)	(0.042)
Household size	0.477	-1.994**	0.534	-1.906**	0.636	-1.952**
	(0.483)	(0.016)	(0.433)	(0.021)	(0.352)	(0.018)
Partner (1=yes)	-0.125	-0.185	-0.137	-0.253	-0.167	-0.338
	(0.828)	(0.785)	(0.812)	(0.713)	(0.771)	(0.623)
Living together with partner (1=yes)	0.157	-0.476	0.093	-0.401	0.117	-0.436
	(0.836)	(0.609)	(0.902)	(0.669)	(0.877)	(0.643)
Married (1=yes)	0.062	0.532	0.123	0.496	0.070	0.592
	(0.891)	(0.331)	(0.787)	(0.366)	(0.877)	(0.282)
Number of children	-0.661	0.537	-0.682	0.526	-0.792	0.558
	(0.214)	(0.374)	(0.200)	(0.385)	(0.139)	(0.358)

Age of respondent	0.052***	-0.016	0.052***	-0.015	0.049***	-0.016
	(0.001)	(0.331)	(0.001)	(0.366)	(0.002)	(0.328)
Log of monthly household income	-0.082	0.121	-0.090	0.110	-0.092	0.125
	(0.588)	(0.473)	(0.550)	(0.514)	(0.541)	(0.459)
Individual is working (1=yes)	-0.751**	-1.224***	-0.720**	-1.187***	-0.739**	-1.265***
	(0.026)	(0.000)	(0.033)	(0.000)	(0.029)	(0.000)
Individual has a higher education degree (1=yes)	-0.248	-0.013	-0.270	-0.006	-0.260	-0.022
	(0.304)	(0.968)	(0.263)	(0.986)	(0.280)	(0.946)
Ratio household members per room	-0.018	5.145**	-0.326	4.770*	-0.442	5.109**
	(0.993)	(0.040)	(0.874)	(0.058)	(0.830)	(0.042)
Individual smoked ever (1=yes)	-0.420	0.223	-0.419	0.235	-0.442	0.308
	(0.135)	(0.453)	(0.135)	(0.430)	(0.114)	(0.302)
Individual smokes currently (1=yes)	-1.052***	-0.668*	-1.089***	-0.661	-1.068***	-0.704*
	(0.001)	(0.099)	(0.000)	(0.103)	(0.000)	(0.082)
Individual is frequent drinker (1=yes)	-0.382	0.112	-0.375	0.122	-0.339	0.079
	(0.106)	(0.710)	(0.112)	(0.685)	(0.150)	(0.794)
Individual practices sports (1=yes)	-0.639***	0.175	-0.640***	0.198	-0.626***	0.219
	(0.005)	(0.520)	(0.005)	(0.466)	(0.005)	(0.420)
Body-Mass-Index	0.125***	0.131***	0.125***	0.132***	0.120***	0.134***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	6583	6569	6583	6569	6583	6569
R-squared	0.090	0.095	0.094	0,0952	0,1010	0,1028
Number of individuals	1943	1939	1943	1939	1943	1939
Socio-Economic controls	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES
Movers excluded	YES	YES	YES	YES	YES	YES

*** Significantly different from 0 at 1 percent level. ** Significantly different from 0 at 5 percent level.

* Significantly different from 0 at 10 percent level.

Appendix table D.2: Effect of housing problems on yearly healthcare visits, male vs. female (full version of table 8)

	Hindrance (%) (Age Q1)	Hindrance (%) (Age Q2)	Hindrance (%) (Age Q3)	Hindrance (%) (Age Q4)	Hindrance (%) (Age Q1)	Hindrance (%) (Age Q2)	Hindrance (%) (Age Q3)	Hindrance (%) (Age Q4)	Hindrance (%) (Age Q1)	Hindrance (%) (Age Q2)	Hindrance (%) (Age Q3)	Hindrance (%) (Age Q4)
Housing problem (t-1)	0.048	0.102**	0.142***	0.116**								
	(0.399)	(0.032)	(0.001)	(0.028)								
Housing problem category (t-1)												
Comfort problems (1=yes)					0.036	0.023	0.184**	0.126				
					(0.677)	(0.763)	(0.025)	(0.323)				
Hazardous problems (1=yes)					-0.001	0.031	0.100*	0.221***				
					(0.990)	(0.642)	(0.087)	(0.002)				
Noise problems (1=yes)					0.054	0.143**	0.084	-0.045				
					(0.480)	(0.035)	(0.172)	(0.548)				
Specific dwelling problems (t-1)												
Too small (1=yes)									0.124	-0.047	0.249**	0.177
									(0.222)	(0.593)	(0.036)	(0.187)
Too dark (1=yes)									-0.172	0.195	0.119	-0.473
									(0.254)	(0.143)	(0.287)	(0.308)
Too cold (1=yes)									-0.029	-0.143	0.023	0.344***
									(0.951)	(0.249)	(0.846)	(0.002)
Leaking roof (1=yes)									-0.228	-0.187	0.211*	-0.176
									(0.608)	(0.164)	(0.072)	(0.254)
Damp walls and floors (1=yes)									0.064	0.120	0.017	0.362**
									(0.635)	(0.243)	(0.856)	(0.031)
Rotten window frames or floors (1=yes)									-0.143	0.201*	0.124	0.127
									(0.380)	(0.079)	(0.194)	(0.276)
Too noisy (1=yes)									0.066	0.153**	0.066	-0.039
									(0.391)	(0.024)	(0.288)	(0.601)
Number of rooms	-0.047	0.041	0.057**	0.004	-0.044	0.041	0.053**	-0.004	-0.057	0.039	0.049*	-0.003
	(0.376)	(0.282)	(0.034)	(0.922)	(0.404)	(0.285)	(0.049)	(0.922)	(0.298)	(0.312)	(0.076)	(0.937)
Log of WOZ-Value	-0.008	0.048	-0.014	-0.040	-0.006	0.045	-0.014	-0.045	0.001	0.036	-0.013	-0.042
	(0.915)	(0.268)	(0.662)	(0.257)	(0.937)	(0.307)	(0.649)	(0.204)	(0.987)	(0.410)	(0.689)	(0.231)
Dwelling satisfaction (0-10)	-0.010	-0.022	0.005	0.000	-0.010	-0.026	0.005	0.003	-0.003	-0.024	0.005	0.003
	(0.714)	(0.295)	(0.777)	(0.981)	(0.717)	(0.238)	(0.775)	(0.865)	(0.905)	(0.274)	(0.771)	(0.889)
Vicinity satisfaction (0-10)	0.003	0.018	-0.04**	-0.030*	0.004	0.020	-0.039**	-0.032*	0.001	0.023	-0.039**	-0.031*
	(0.880)	(0.390)	(0.015)	(0.070)	(0.857)	(0.326)	(0.016)	(0.053)	(0.969)	(0.259)	(0.018)	(0.062)
Vicinity problems												
Vicinity noise (neighbours) (1=yes)	0.083	0.035	0.057	-0.005	0.080	0.029	0.067	0.019	0.106*	0.026	0.072*	0.013
	(0.163)	(0.470)	(0.169)	(0.924)	(0.184)	(0.561)	(0.117)	(0.718)	(0.089)	(0.602)	(0.094)	(0.810)
Vicinity noise (street) (1=yes)	0.025	0.043	0.040	0.043	0.024	0.040	0.037	0.032	0.001	0.039	0.033	0.037
	(0.764)	(0.463)	(0.395)	(0.397)	(0.781)	(0.502)	(0.431)	(0.524)	(0.993)	(0.505)	(0.490)	(0.457)
Vicinity pollution (1=yes)	-0.115	0.110	0.102	-0.061	-0.121	0.110	0.100	-0.060	-0.147	0.106	0.094	-0.041
	(0.315)	(0.164)	(0.100)	(0.448)	(0.291)	(0.165)	(0.109)	(0.457)	(0.205)	(0.180)	(0.134)	(0.618)
Vicinity crime (1=yes)	-0.113	0.091	-0.005	0.119*	-0.109	0.087	-0.006	0.108*	-0.110	0.097	-0.015	0.106
	(0.247)	(0.261)	(0.934)	(0.070)	(0.269)	(0.284)	(0.925)	(0.099)	(0.284)	(0.239)	(0.812)	(0.108)
Household size	0.059	0.133	-0.210*	-0.166	0.050	0.145	-0.200**	-0.142	0.035	0.152	-0.180**	-0.147
	(0.683)	(0.226)	(0.019)	(0.130)	(0.727)	(0.188)	(0.026)	(0.197)	(0.809)	(0.168)	(0.049)	(0.182)
Partner (1=yes)	0.111	-0.247***	-0.084	-0.015	0.114	-0.259***	-0.091	-0.027	0.147	-0.282***	-0.106	-0.026
	(0.307)	(0.002)	(0.237)	(0.868)	(0.312)	(0.001)	(0.203)	(0.764)	(0.205)	(0.000)	(0.141)	(0.777)
Living together with partner (1=yes)	-0.084	0.005	0.014	0.135	-0.089	0.006	0.020	0.132	-0.096	-0.015	0.022	0.120
	(0.539)	(0.964)	(0.902)	(0.318)	(0.517)	(0.956)	(0.860)	(0.328)	(0.495)	(0.898)	(0.847)	(0.373)
Married (1=yes)	-0.017	0.020	0.071	-0.078	-0.017	0.016	0.067	-0.067	-0.021	0.032	0.070	-0.055
	(0.770)	(0.724)	(0.384)	(0.476)	(0.774)	(0.783)	(0.412)	(0.542)	(0.718)	(0.569)	(0.392)	(0.616)
Number of children	0.024	-0.220**	0.040	0.115	0.030	-0.232**	0.034	0.103	0.064	-0.237**	0.019	0.119
	(0.841)	(0.017)	(0.537)	(0.128)	(0.800)	(0.012)	(0.596)	(0.180)	(0.609)	(0.010)	(0.772)	(0.124)
Age of respondent	-0.004	0.008	-0.004	0.016***	-0.004	0.009	-0.004	0.016***	-0.004	0.008	-0.005	0.016***
	(0.438)	(0.152)	(0.469)	(0.000)	(0.453)	(0.111)	(0.399)	(0.000)	(0.447)	(0.160)	(0.315)	(0.000)
Log of monthly household income	-0.002	-0.009	-0.043**	-0.010	-0.001	-0.009	-0.044**	-0.014	0.001	-0.010	-0.043**	-0.011
	(0.951)	(0.704)	(0.012)	(0.614)	(0.973)	(0.706)	(0.011)	(0.487)	(0.963)	(0.665)	(0.012)	(0.558)
Individual is working (1=yes)	-0.123*	-0.242***	-0.066**	-0.141	-0.126*	-0.241***	-0.067**	-0.136	-0.118	-0.239***	-0.065**	-0.132
	(0.085)	(0.000)	(0.039)	(0.157)	(0.080)	(0.000)	(0.037)	(0.173)	(0.104)	(0.000)	(0.041)	(0.188)
Individual has a higher education degree (1=yes)	-0.020	-0.050	-0.015	-0.033	-0.021	-0.049	-0.016	-0.033	-0.021	-0.039	-0.017	-0.031
	(0.681)	(0.180)	(0.634)	(0.340)	(0.674)	(0.192)	(0.610)	(0.348)	(0.663)	(0.303)	(0.578)	(0.374)
Ratio household members per room	-0.419	0.151	0.868***	0.448	-0.414	0.150	0.821***	0.343	-0.480	0.178	0.762**	0.338
	(0.226)	(0.625)	(0.004)	(0.256)	(0.234)	(0.630)	(0.006)	(0.386)	(0.173)	(0.567)	(0.012)	(0.394)
Individual smoked ever (1=yes)	0.003	-0.031	-0.012	0.002	0.006	-0.034	-0.015	0.001	-0.005	-0.032	-0.014	0.002
	(0.948)	(0.455)	(0.735)	(0.951)	(0.904)	(0.416)	(0.669)	(0.977)	(0.926)	(0.440)	(0.690)	(0.961)
Individual smokes currently (1=yes)	0.005	-0.018	0.009	0.032	0.004	-0.009	0.008	0.022	0.007	-0.021	0.009	0.021
	(0.945)	(0.714)	(0.817)	(0.461)	(0.958)	(0.858)	(0.825)	(0.609)	(0.928)	(0.671)	(0.803)	(0.638)
Individual is frequent drinker (1=yes)	0.012	0.091**	-0.003	-0.064**	0.014	0.084**	0.001	-0.067**	0.026	0.077**	0.004	-0.068**
	(0.842)	(0.019)	(0.916)	(0.034)	(0.807)	(0.031)	(0.973)	(0.026)	(0.664)	(0.047)	(0.891)	(0.023)
Individual practices sports (1=yes)	0.038	-0.115***	-0.107***	-0.043	0.038	-0.117***	-0.107***	-0.041	0.040	-0.115***	-0.106***	-0.044
	(0.393)	(0.003)	(0.000)	(0.144)	(0.393)	(0.002)	(0.000)	(0.158)	(0.372)	(0.003)	(0.000)	(0.134)
Body-Mass-Index	0.007	0.012***	0.003	0.010***	0.007	0.011**	0.003	0.009***	0.007	0.011**	0.003	0.009***
	(0.108)	(0.008)	(0.394)	(0.006)	(0.110)	(0.015)	(0.413)	(0.008)	(0.115)	(0.010)	(0.431)	(0.008)
R-squared	0.068	0.192	0.099	0.109	0.068	0.193	0.100	0.115	0.078	0.207	0.104	0.122
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
Movers excluded	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

*** Significantly different from 0 at 1 percent level. ** Significantly different from 0 at 5 percent level. * Significantly different from 0 at 10 percent level.

Appendix Table D.3: Effect of housing problems on hindrance, by age quartiles (full version of table 9)

	Healthcare visits (Age Q1)	Healthcare visits (Age Q2)	Healthcare visits (Age Q3)	Healthcare visits (Age Q4)	Healthcare visits (Age Q1)	Healthcare visits (Age Q2)	Healthcare visits (Age Q3)	Healthcare visits (Age Q4)	Healthcare visits (Age Q1)	Healthcare visits (Age Q2)	Healthcare visits (Age Q3)	Healthcare visits (Age Q4)
Housing problem (t-1)	0.856	0.725	0.767**	-0.627								
	(0.158)	(0.143)	(0.042)	(0.335)								
Housing problem category (t-1)												
Comfort problems (t-1) (1=yes)					1.685*	0.926	0.134	-0.249				
					(0.064)	(0.248)	(0.850)	(0.875)				
Hazardous problems (t-1) (1=yes)					0.139	0.091	1.399***	0.317				
					(0.194)	(0.897)	(0.005)	(0.726)				
Noise problems (t-1) (1=yes)					-0.531	0.083	0.538	-0.930				
					(0.516)	(0.908)	(0.304)	(0.319)				
Specific dwelling problems (t-1)												
Too small (1=yes)									0.376	-1.419	0.724	0.060
									(0.725)	(0.117)	(0.469)	(0.971)
Too dark (1=yes)									4.606***	5.341***	-0.643	-4.288
									(0.004)	(0.000)	(0.509)	(0.459)
Too cold (1=yes)									-1.823	0.759	0.540	-0.159
									(0.712)	(0.554)	(0.592)	(0.909)
Leaking roof (1=yes)									0.156	-1.177	4.705***	2.403
									(0.974)	(0.397)	(0.000)	(0.211)
Damp walls and floors (1=yes)									-0.693	0.671	-0.747	-0.688
									(0.625)	(0.529)	(0.348)	(0.743)
Rotten window frames or floors (1=yes)									4.443**	0.684	1.479*	0.707
									(0.010)	(0.565)	(0.066)	(0.625)
Too noisy (1=yes)									-0.777	0.142	0.281	-0.106
									(0.340)	(0.841)	(0.592)	(0.258)
Number of rooms	-0.182	-0.001	0.174	0.553	-0.261	0.006	0.161	0.545	0.004	0.002	0.042	0.498
	(0.748)	(0.999)	(0.455)	(0.219)	(0.646)	(0.987)	(0.487)	(0.228)	(0.995)	(0.996)	(0.854)	(0.271)
Log of WOZ-Value	-0.079	1.603	0.130	-0.159	-0.129	1.604	0.131	-0.172	-0.253	1.448	0.190	-0.143
	(0.919)	(0.000)	(0.630)	(0.717)	(0.869)	(0.000)	(0.627)	(0.696)	(0.746)	(0.001)	(0.474)	(0.746)
Dwelling satisfaction (0-10)	0.026	-0.420	0.154	0.115	0.112	-0.436	0.176	0.134	-0.024	-0.468	0.202	0.147
	(0.925)	(0.060)	(0.332)	(0.631)	(0.693)	(0.053)	(0.267)	(0.578)	(0.934)	(0.038)	(0.204)	(0.541)
Vicinity satisfaction (0-10)	-0.076	0.057	-0.477	0.052	-0.159	0.049	-0.481	0.044	-0.074	0.074	-0.476	0.029
	(0.747)	(0.790)	(0.001)	(0.804)	(0.506)	(0.819)	(0.001)	(0.834)	(0.760)	(0.726)	(0.001)	(0.889)
Vicinity problems												
Vicinity noise (neighbours) (1=yes)	0.922	0.384	-0.021	-1.107*	0.974	0.424	0.011	-1.042	0.590	0.515	0.090	-1.026
	(0.149)	(0.446)	(0.952)	(0.084)	(0.130)	(0.410)	(0.976)	(0.112)	(0.371)	(0.313)	(0.803)	(0.118)
Vicinity noise (street) (1=yes)	0.184	-0.155	0.343	0.026	-0.170	-0.228	0.288	-0.008	0.253	-0.228	0.178	-0.059
	(0.838)	(0.801)	(0.397)	(0.967)	(0.852)	(0.713)	(0.476)	(0.990)	(0.783)	(0.713)	(0.657)	(0.925)
Vicinity pollution (1=yes)	-2.011	0.633	1.848***	-0.361	-1.969	0.585	1.827***	-0.331	-1.698	0.400	1.633***	-0.459
	(0.100)	(0.441)	(0.001)	(0.719)	(0.106)	(0.478)	(0.001)	(0.743)	(0.164)	(0.626)	(0.002)	(0.652)
Vicinity crime (1=yes)	-0.137	-0.126	0.560	2.316***	-0.148	-0.095	0.533	0.230***	-1.166	-0.389	0.387	2.280***
	(0.190)	(0.881)	(0.312)	(0.005)	(0.157)	(0.911)	(0.335)	(0.005)	(0.281)	(0.649)	(0.480)	(0.006)
Household size	-1.413	0.917	-0.744	-2.438*	-1.211	0.885	-0.678	-2.421*	-1.111	1.098	-0.215	-2.255
	(0.356)	(0.423)	(0.331)	(0.074)	(0.428)	(0.442)	(0.376)	(0.078)	(0.472)	(0.336)	(0.781)	(0.102)
Partner (1=yes)	2.821**	-0.347	-0.141**	-0.485	2.435**	-0.386	-1.468**	-0.554	2.065*	-0.262	-1.708***	-0.632
	(0.015)	(0.671)	(0.020)	(0.667)	(0.043)	(0.639)	(0.016)	(0.624)	(0.092)	(0.750)	(0.005)	(0.577)
Living together with partner (1=yes)	-0.212	0.576	-0.247	0.800	-1.870	0.582	-0.253	0.795	-1.856	-0.124	-0.239	0.821
	(0.145)	(0.625)	(0.795)	(0.633)	(0.200)	(0.622)	(0.791)	(0.636)	(0.213)	(0.916)	(0.799)	(0.626)
Married (1=yes)	0.632	0.320	1.401**	-0.226	0.591	0.323	1.425**	-0.147	0.653	0.476	1.433**	-0.112
	(0.307)	(0.589)	(0.044)	(0.868)	(0.338)	(0.589)	(0.041)	(0.914)	(0.288)	(0.421)	(0.038)	(0.935)
Number of children	0.793	-0.137	0.216	-0.044	0.694	-1.334	0.144	0.007	0.261	-1.482	-0.211	-0.175
	(0.534)	(0.151)	(0.696)	(0.962)	(0.586)	(0.165)	(0.795)	(0.994)	(0.842)	(0.119)	(0.702)	(0.856)
Age of respondent	-0.001	0.049	-0.060	0.027	0.001	0.050	-0.057	0.028	0.005	0.034	-0.075*	0.026
	(0.993)	(0.395)	(0.189)	(0.413)	(0.981)	(0.393)	(0.210)	(0.399)	(0.930)	(0.554)	(0.096)	(0.430)
Log of monthly household income	0.284	-0.056	-0.257*	0.220	0.300	-0.092	-0.249*	0.209	0.284	-0.049	-0.253*	0.186
	(0.388)	(0.821)	(0.083)	(0.363)	(0.361)	(0.710)	(0.092)	(0.389)	(0.385)	(0.841)	(0.084)	(0.445)
Individual is working (1=yes)	-2.065***	-2.763***	-0.646**	-0.742	-2.001***	-2.676	-0.616**	-0.674	-0.221***	-2.745***	-0.600**	-0.638
	(0.007)	(0.000)	(0.019)	(0.548)	(0.009)	(0.000)	(0.025)	(0.588)	(0.004)	(0.000)	(0.027)	(0.609)
Individual has a higher education degree (1=yes)	0.777	-0.836**	0.017	-0.448	0.849	-0.832**	0.034	-0.468	0.903*	-0.787*	0.047	-0.481
	(0.136)	(0.032)	(0.948)	(0.299)	(0.103)	(0.033)	(0.898)	(0.278)	(0.083)	(0.043)	(0.858)	(0.267)
Ratio household members per room	2.874	-0.150	0.976	0.954*	2.463	-1.580	0.828	9.381*	0.370	-1.373	-0.490	8.850*
	(0.437)	(0.641)	(0.701)	(0.052)	(0.505)	(0.626)	(0.745)	(0.057)	(0.319)	(0.670)	(0.847)	(0.074)
Individual smoked ever (1=yes)	0.824	-0.253	0.016	-0.364	0.854	-0.232	0.026	-0.354	1.000*	-0.071	0.037	-0.392
	(0.118)	(0.562)	(0.958)	(0.404)	(0.105)	(0.596)	(0.928)	(0.418)	(0.059)	(0.871)	(0.899)	(0.373)
Individual smokes currently (1=yes)	-0.164	-1.259**	-1.056***	-0.898*	-0.083	-1.288**	-1.033***	-0.931*	-0.136	-1.322***	-1.011***	-0.943*
	(0.835)	(0.012)	(0.001)	(0.096)	(0.916)	(0.011)	(0.001)	(0.086)	(0.862)	(0.009)	(0.002)	(0.084)
Individual is frequent drinker (1=yes)	1.228*	-0.099	-0.416	-0.404	1.086*	-0.088	-0.404	-0.425	0.950	-0.200	-0.347	-0.398
	(0.050)	(0.806)	(0.103)	(0.280)	(0.084)	(0.829)	(0.112)	(0.256)	(0.131)	(0.621)	(0.168)	(0.289)
Individual practices sports (1=yes)	0.477	-0.614	0.036	-0.910**	0.435	-0.592	0.041	-0.905**	0.451	-0.511	0.054	-0.887**
	(0.320)	(0.124)	(0.881)	(0.013)	(0.364)	(0.140)	(0.866)	(0.013)	(0.344)	(0.201)	(0.824)	(0.015)
Body-Mass-Index	0.237***	0.062	0.118***	0.056	0.228***	0.059	0.115***	0.055	0.229***	0.061	0.110***	0.054
	(0.000)	(0.166)	(0.001)	(0.205)	(0.000)	(0.193)	(0.001)	(0.213)	(0.000)	(0.176)	(0.001)	(0.222)
R-squared	0.175	0.168	0.130	0.052	0.184	0.167	0.134	0.052	0.205	0.191	0.158	0.054
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
Movers excluded	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

*** Significantly different from 0 at 1 percent level. ** Significantly different from 0 at 5 percent level. * Significantly different from 0 at 10 percent level.

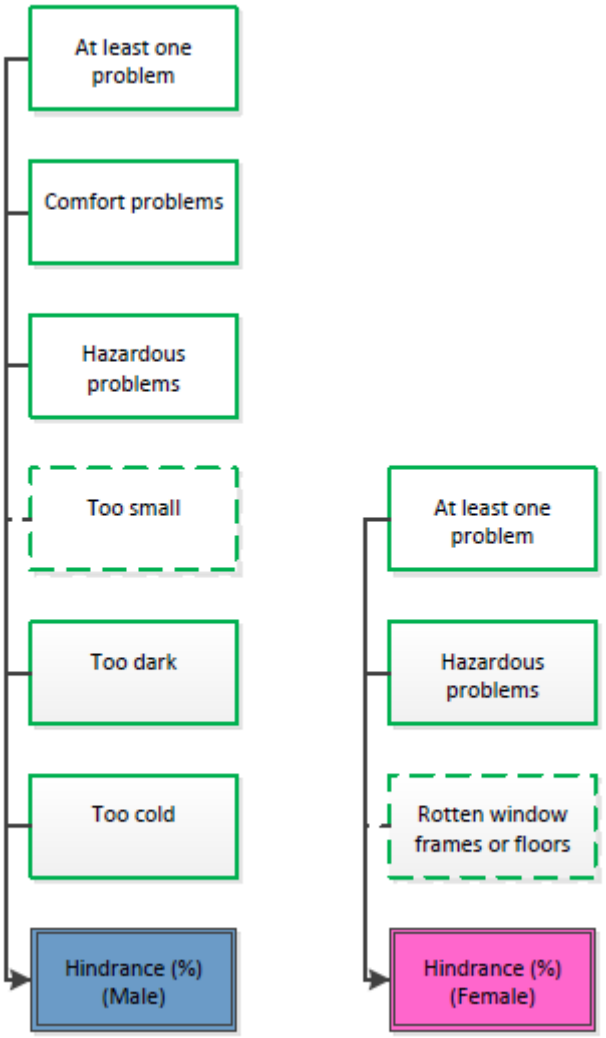
Appendix Table D.4: Effect of housing problems on yearly healthcare visits, by age quartiles (full version of table 10)

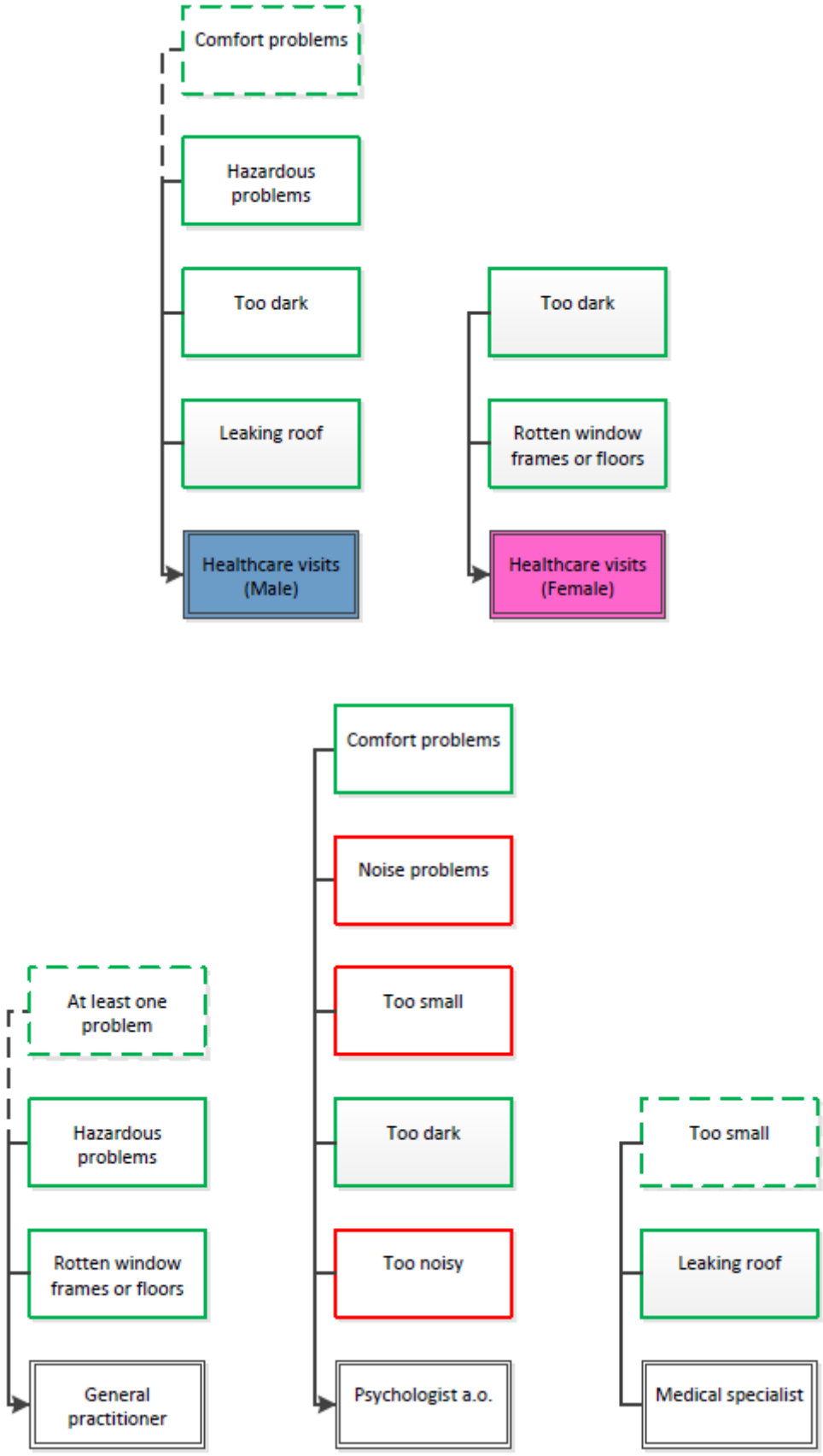
	General practitioner	General practitioner	General practitioner	Psychologist a.o	Psychologist a.o	Psychologist a.o	Medical specialist	Medical specialist	Medical specialist
Housing problem (t-1)	0.229*			0.070			0.252		
	(0.096)			(0.507)			(0.105)		
Housing problem category (t-1)									
Comfort problems (1=yes)		0.064			0.669***			0.333	
		(0.792)			(0.000)			(0.226)	
Hazardous problems (1=yes)		0.652***			-0.114			0.310	
		(0.001)			(0.444)			(0.161)	
Noise problems (1=yes)		-0.015			-0.359**			0.121	
		(0.938)			(0.014)			(0.579)	
Specific dwelling problems (t-1)									
Too small (1=yes)			-0.065			-0.577***			0.555*
			(0.822)			(0.009)			(0.093)
Too dark (1=yes)			0.263			2.906***			-0.092
			(0.515)			(0.000)			(0.838)
Too cold (1=yes)			0.309			-0.103			0.006
			(0.386)			(0.701)			(0.988)
Leaking roof (1=yes)			0.644			0.210			1.275***
			(0.114)			(0.494)			(0.006)
Damp walls and floors (1=yes)			0.428			-0.168			-0.331
			(0.175)			(0.478)			(0.354)
Rotten window frames or floors (1=yes)			0.897***			0.027			0.544
			(0.005)			(0.910)			(0.129)
Too noisy (1=yes)			-0.042			-0.338**			0.077
			(0.829)			(0.020)			(0.725)
Number of rooms	-0.030	-0.031	-0.033	0.108	0.099	0.122*	0.043	0.035	0.023
	(0.740)	(0.730)	(0.714)	(0.115)	(0.151)	(0.071)	(0.674)	(0.733)	(0.820)
Log of WOZ-Value	-0.136	-0.137	-0.141	0.312***	0.304***	0.281***	0.071	0.073	0.083
	(0.216)	(0.213)	(0.198)	(0.000)	(0.000)	(0.001)	(0.568)	(0.559)	(0.502)
Dwelling satisfaction (0-10)	0.110*	0.122**	0.128**	-0.134***	-0.130***	-0.143***	0.097	0.105	0.117*
	(0.055)	(0.032)	(0.026)	(0.002)	(0.003)	(0.001)	(0.133)	(0.105)	(0.072)
Vicinity satisfaction (0-10)	-0.039	-0.045	-0.043	-0.045	-0.052	-0.039	-0.094	-0.098*	-0.105*
	(0.440)	(0.380)	(0.404)	(0.248)	(0.180)	(0.305)	(0.103)	(0.090)	(0.068)
Vicinity problems									
Vicinity noise (neighbours) (1=yes)	0.012	0.051	0.062	0.114	0.157	0.167	-0.232	-0.225	-0.208
	(0.932)	(0.711)	(0.654)	(0.275)	(0.136)	(0.109)	(0.132)	(0.151)	(0.184)
Vicinity noise (street) (1=yes)	0.055	0.032	0.028	-0.079	-0.103	-0.062	0.168	0.144	0.128
	(0.722)	(0.839)	(0.857)	(0.505)	(0.385)	(0.595)	(0.337)	(0.413)	(0.467)
Vicinity pollution (1=yes)	0.159	0.158	0.147	0.243	0.236	0.187	0.167	0.160	0.108
	(0.463)	(0.466)	(0.500)	(0.142)	(0.153)	(0.252)	(0.495)	(0.513)	(0.662)
Vicinity crime (1=yes)	-0.193	-0.222	-0.240	0.260*	0.281*	0.264*	0.694***	0.685***	0.654***
	(0.348)	(0.280)	(0.243)	(0.097)	(0.072)	(0.089)	(0.003)	(0.003)	(0.005)
Household size	-0.012	-0.004	-0.006	-0.283	-0.257	-0.316	-0.233	-0.206	-0.145
	(0.966)	(0.989)	(0.984)	(0.176)	(0.219)	(0.128)	(0.453)	(0.508)	(0.643)
Partner (1=yes)	-0.046	-0.038	-0.056	0.268	0.240	0.257	-0.537**	-0.551**	-0.581**
	(0.841)	(0.867)	(0.809)	(0.126)	(0.171)	(0.137)	(0.039)	(0.034)	(0.026)
Living together with partner (1=yes)	0.147	0.128	0.135	-0.714***	-0.690***	-0.732***	0.523	0.524	0.528
	(0.633)	(0.678)	(0.661)	(0.002)	(0.003)	(0.002)	(0.135)	(0.134)	(0.131)
Married (1=yes)	-0.002	0.005	0.010	0.354**	0.350**	0.358**	-0.134	-0.129	-0.129
	(0.992)	(0.979)	(0.955)	(0.012)	(0.012)	(0.010)	(0.518)	(0.536)	(0.535)
Number of children	-0.080	-0.091	-0.091	0.025	0.032	0.067	-0.053	-0.067	-0.122
	(0.703)	(0.665)	(0.665)	(0.876)	(0.840)	(0.673)	(0.822)	(0.777)	(0.610)
Age of respondent	0.020***	0.020***	0.020***	-0.019***	-0.018***	-0.019***	0.011	0.01*	0.010
	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.101)	(0.099)	(0.142)

Log of monthly household income	-0.020	-0.022	-0.021	-0.054	-0.061	-0.064	0.065	0.064	0.063
	(0.734)	(0.714)	(0.716)	(0.232)	(0.174)	(0.150)	(0.328)	(0.341)	(0.346)
Individual is working (1=yes)	-0.585***	-0.578***	-0.581***	-0.094	-0.077	-0.137	-0.478***	-0.468***	-0.463***
	(0.000)	(0.000)	(0.000)	(0.310)	(0.407)	(0.134)	(0.000)	(0.001)	(0.001)
Individual is studying (1=yes)	0.793	0.822	0.816	-0.276	-0.262	-0.306	-0.963	-0.954	-0.970
	(0.747)	(0.738)	(0.739)	(0.883)	(0.889)	(0.868)	(0.729)	(0.732)	(0.727)
Individual has a higher education degree (1=ye	-0.168*	-0.167*	-0.162	0.045	0.035	0.042	-0.126	-0.126	-0.130
	(0.093)	(0.094)	(0.105)	(0.554)	(0.646)	(0.577)	(0.266)	(0.264)	(0.248)
Ratio household members per room	-0.071	-0.062	-0.031	1.253**	1.061*	1.348538**	0.660	0.560	0.435
	(0.931)	(0.941)	(0.970)	(0.047)	(0.093)	(0.031)	(0.480)	(0.551)	(0.644)
Individual smoked ever (1=yes)	0.026	0.027	0.028	-0.007	-0.006	0.030	-0.116	-0.117	-0.123
	(0.807)	(0.801)	(0.794)	(0.926)	(0.946)	(0.704)	(0.335)	(0.329)	(0.305)
Individual smokes currently (1=yes)	-0.530***	-0.528***	-0.534***	-0.063	-0.078	-0.086	-0.499***	-0.500***	-0.503***
	(0.000)	(0.000)	(0.000)	(0.514)	(0.417)	(0.369)	(0.001)	(0.001)	(0.000)
Individual is frequent drinker (1=yes)	-0.301***	-0.304***	-0.298***	-0.013	-0.008	-0.028	0.044	0.045	0.063
	(0.002)	(0.002)	(0.002)	(0.864)	(0.910)	(0.702)	(0.689)	(0.681)	(0.563)
Individual practices sports (1=yes)	-0.061	-0.064	-0.061	-0.046	-0.042	-0.033	-0.203*	-0.204**	-0.200*
	(0.502)	(0.480)	(0.502)	(0.514)	(0.546)	(0.630)	(0.050)	(0.049)	(0.053)
Body-Mass-Index	0.061***	0.060***	0.061***	0.026***	0.027***	0.028***	0.016	0.015	0.014
	(0.000)	(0.000)	(0.000)	(0.002)	(0.001)	(0.001)	(0.215)	(0.231)	(0.256)
Observations	13100	13100	13100	13100	13100	13100	13100	13100	13100
R-squared	0.081	0.083	0.086	0.041	0.046	0.073	0.050	0.051	0.054
Number of individuals	3882	3882	3882	3882	3882	3882	3882	3882	3882
Socio-Economic controls	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES	YES	YES	YES
Movers excluded	YES	YES	YES	YES	YES	YES	YES	YES	YES

*** Significantly different from 0 at 1 percent level. ** Significantly different from 0 at 5 percent level. * Significantly different from 0 at 10 percent level.

Appendix table D.5: Effect of housing problems on different types of healthcare visits (full version of table 11)


At least one problem
Comfort problems
Hazardous problems
Too small
Too dark
Too cold
Hindrance (%) (Male)
At least one problem
Hazardous problems
Rotten window frames or floors
Hindrance (%) (Female)



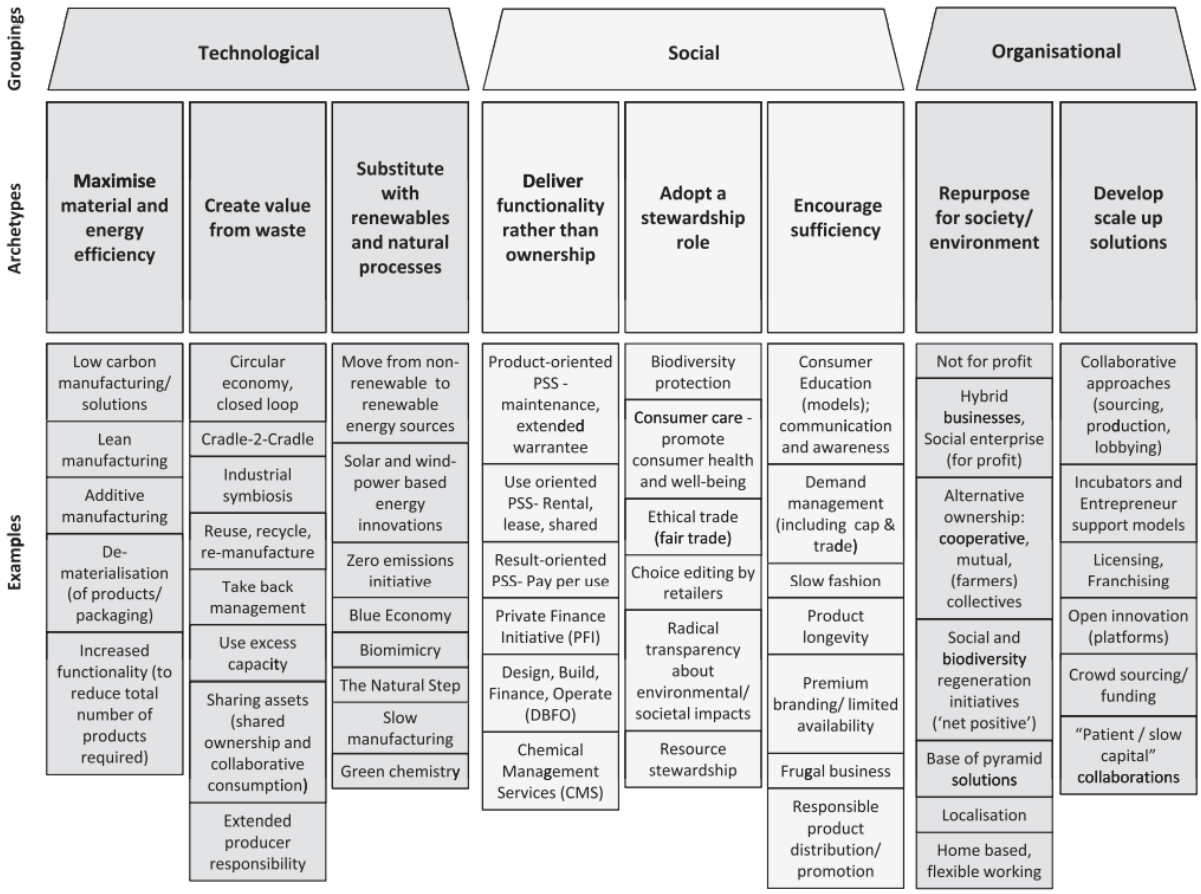
Appendix figure D.6: Visual summary of all significant relations involving cost indicators.

	Log WOZ-Value (Single fam. detached)	Log WOZ-Value (Single fam. corner)	Log WOZ-Value (Single fam. duplex)	Log WOZ-Value (Single fam. row)	Log WOZ-Value (Apartment)	Log WOZ-Value (Other)
Housing problem (t-1)	-0.097*	-0.015	-0.114**	-0.031	-0.113**	0.074
	(0.080)	(0.705)	(0.016)	(0.411)	(0.012)	(0.508)
Number of rooms	0.205***	0.198***	0.069**	0.192***	0.082**	0.116
	(0.000)	(0.000)	(0.048)	(0.000)	(0.031)	(0.115)
Dwelling satisfaction (0-10)	0.008	0.034*	0.059***	-0.004	0.047**	-0.028
	(0.672)	(0.053)	(0.001)	(0.828)	(0.013)	(0.553)
Vicinity satisfaction (0-10)	0.043***	0.016	0.015	0.034**	0.006	0.051
	(0.008)	(0.269)	(0.375)	(0.023)	(0.737)	(0.276)
Vicinity problems						
Vicinity noise (neighbours) (1=yes)	0.078	0.077*	0.067	-0.027	0.041	-0.078
	(0.154)	(0.061)	(0.139)	(0.458)	(0.342)	(0.640)
Vicinity noise (street) (1=yes)	0.047	0.023	0.000	-0.012	0.044	-0.093
	(0.365)	(0.668)	(0.992)	(0.815)	(0.346)	(0.529)
Vicinity pollution (1=yes)	-0.080	-0.034	-0.005	-0.160**	0.012	-0.029
	(0.316)	(0.609)	(0.947)	(0.028)	(0.835)	(0.890)
Vicinity crime (1=yes)	-0.254***	-0.044	0.040	-0.029	-0.059	-0.323
	(0.000)	(0.419)	(0.625)	(0.650)	(0.279)	(0.161)
Household size	-0.055	-0.260***	0.034	-0.262***	0.048	-0.171
	(0.534)	(0.006)	(0.710)	(0.001)	(0.679)	(0.447)
Partner (1=yes)	-0.315***	0.069	0.054	-0.018	-0.039	0.225
	(0.002)	(0.311)	(0.439)	(0.775)	(0.494)	(0.284)
Living together with partner (1=yes)	0.134	0.093	0.321***	0.058	0.168	0.591**
	(0.297)	(0.274)	(0.000)	(0.485)	(0.114)	(0.016)
Married (1=yes)	0.059	-0.103**	-0.217***	0.029	-0.058	-0.593***
	(0.437)	(0.027)	(0.000)	(0.588)	(0.417)	(0.000)
Number of children	-0.138**	0.106*	0.039	0.130**	-0.057	0.082
	(0.047)	(0.091)	(0.525)	(0.030)	(0.551)	(0.623)
Age of respondent	-0.001	0.006***	0.007***	0.006***	0.005***	0.009*
	(0.814)	(0.002)	(0.000)	(0.000)	(0.008)	(0.067)
Log of monthly household income	0.056***	0.052***	0.053***	0.048**	0.108***	0.030
	(0.004)	(0.002)	(0.006)	(0.012)	(0.000)	(0.577)
Individual is working (1=yes)	-0.089**	0.025	-0.011	0.043	-0.026	0.161*
	(0.027)	(0.553)	(0.769)	(0.232)	(0.626)	(0.098)
Individual has a higher education degree (1=yes)	0.112***	0.172***	0.099***	0.105***	0.093***	0.229*
	(0.001)	(0.000)	(0.001)	(0.001)	(0.009)	(0.062)
Ratio household members per room	1.160***	0.968***	-0.259	0.773***	0.213	0.190
	(0.000)	(0.002)	(0.415)	(0.002)	(0.399)	(0.810)
Individual smoked ever (1=yes)	0.035	-0.011	-0.080**	-0.106***	-0.021	-0.310***
	(0.336)	(0.748)	(0.013)	(0.001)	(0.603)	(0.006)
Individual smokes currently (1=yes)	0.015	-0.006	-0.095**	-0.011	-0.043	0.154
	(0.726)	(0.881)	(0.015)	(0.791)	(0.323)	(0.163)
Individual is frequent drinker (1=yes)	0.159***	0.020	0.072**	0.070**	0.138***	0.022
	(0.000)	(0.525)	(0.011)	(0.023)	(0.000)	(0.834)
Individual practices sports (1=yes)	0.078**	0.085***	0.025	0.052*	-0.059*	0.095
	(0.015)	(0.003)	(0.393)	(0.068)	(0.075)	(0.271)
Body-Mass-Index	-0.001	-0.002	-0.004	-0.003	0.002	0.020**
	(0.745)	(0.512)	(0.234)	(0.435)	(0.580)	(0.037)
Observations	3410	2476	3230	4873	1999	1059
R-squared	0.284	0.316	0.270	0.197	0.375	0.378
Number of individuals	899	583	851	1054	520	164
Socio-Economic controls	YES	YES	YES	YES	YES	YES
Year fixed effects	YES	YES	YES	YES	YES	YES

*** Significantly different from 0 at 1 percent level. ** Significantly different from 0 at 5 percent level. * Significantly different from 0 at 10 percent level.

Appendix figure D.7: Effects of at least one housing problem on WOZ-value per type (full version of table 12)

Appendix E – Sustainable business models



Appendix figure E.1: Sustainable business model archetypes (Bocken et al., 2008)