"Damp in bathroom. Damp in back room. It's very depressing!"

Exploring the Relationship between Perceived Housing Problems, Energy Affordability Concerns, and Health and Well-Being in UK Social Housing

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Abstract

Social housing residents often struggle with achieving adequate levels of warmth in their home on a limited household budget. Additionally, other housing problems such as damp are common. Previous research has found a link between housing problems and poor health and reduced well-being, but this relationship is complex and poorly understood. A survey among UK social housing residents (N = 536) investigated the association between cold and damp housing, as well as the role of energy affordability concerns in the relationship between housing problems and health. The findings indicated that struggles with keeping warm related to a cluster of damp and mould issues rather than any one specific issue. In describing these problems householders expressed a sense of frustration and helplessness. Support was found for an indirect effect on health whereby households experiencing cold, damp or mould issues reported more difficulty with affording their energy bills, these affordability concerns in turn related to poor health and well-being. The effects were found to be more consistent and stronger for men compared to women. Policies aimed at reducing housing problems should consider the important role of affordability concerns and the need for households to regain control of their energy bills.

Keywords: Social housing; Housing problems; Energy affordability; Health; Well-being

1. Introduction

Social housing is provided by most European countries for vulnerable or low income households (European Parliament, 2013). Also referred to as affordable housing, it provides houses for people who would otherwise struggle to buy their own home or afford a privately rented home. A key concern in the social housing sector is the high proportion of people in fuel poverty (Healy and Clinch, 2004). Approximately 10 percent of the European population experience fuel poverty, this number increases to almost 25 percent for low income households (Pittini et al., 2015). A common European definition of fuel poverty is lacking, but it is often described as the inability to keep the home adequately warm – resulting mainly from low household income, high energy costs and poor energy efficiency of the house (Antanasiu et al., 2014). Consequently, many low income households live in damp and cold conditions as they are not able to afford heating their home comfortably and adequately in winter (Hills, 2012; Liddell, 2008). Indeed, social housing tenants tend to experience more housing problems (e.g. cold housing, damp, mould, condensation) than owner-occupiers (Pevalin et al., 2008). Preventing

health impacts resulting from these housing problems is now part of the rationale to tackle fuel poverty (Liddell and Morris, 2010). Overall, fuel poverty and the effect it has on households is part of a complex relationship that encompasses not only income, but also dwelling characteristics, householder behaviour and health and well-being. Understanding this complex relationship is important in explaining and predicting the effect of measures targeting fuel poverty and housing problems. This paper discusses the findings from a survey conducted among social housing residents in the United Kingdom (UK). The research takes a two-part approach: first, the study examines householders' self-reported experiences with cold, condensation, damp and mould using both quantitative and qualitative responses, particularly focusing on the specific housing problems associated with cold housing. Second, it examines the relationship between housing problems (cold, condensation, damp and mould) and health and well-being reported. Importantly, the research investigates the role of energy affordability concerns within this relationship – it asks whether worries about energy costs may partly underlie the association between housing problems and low health and well-being. Before describing the aims of the study in more detail, we review the literature on housing problems and their proposed relationship with health and well-being.

1.1. The Effect of Cold and Damp Housing on Physical Health

Reducing exposure to cold housing, and especially providing access to affordable warmth, has been acknowledged as a priority in attempts to tackle health issues associated with poor housing (Pevalin et al., 2008). A cold house may affect health by increasing blood pressure, reducing resistance to infections associated with colds, and increasing the risk of influenza, asthma, seasonal mortality and heart attacks (see Evans et al., 2000; Liddell and Morris, 2010; and Maidment et al., 2014 for an overview). Furthermore, a cold home is associated with further housing problems such as damp, condensation and mould (Healy and Clinch, 2004). Indeed, fuel poverty has been linked to increased risk of mould contamination, this relationship was found even when controlling for differences in heating and ventilation behaviours (Sharpe et al., 2015b). Damp, condensation and mould present additional health risks; a damp home can increase the presence of house-dust mites and moulds, these are recognised as important environmental causes of asthma and other respiratory problems (Peat et al., 1998; Sharpe et al., 2015a). A wide range of health problems have been associated with damp housing, leading some to suggest that damp housing may increase susceptibility to poor health in general (Evans et al., 2000).

Increasingly it is being recognised that energy-efficiency improvements, in addition to reducing carbon emissions, could also play an important role in tackling fuel poverty and health inequalities by reducing housing problems (Maidment et al., 2014). Evaluating the effect of

these home upgrades (e.g. thermal upgrades and more efficient heating systems and controls) could provide further insight into the relationship between housing problems and health. In these evaluation studies, health is typically assessed before and after home upgrades have been made in an attempt to identify a causal pathway between the experience of housing problems and poor health. Two recent review papers have attempted to bring together the available evidence to provide clearer support for the link between reducing housing problems and improved health. Maidment et al. (2014) conducted a systematic review of 36 studies examining health impacts of energy efficiency interventions aimed at reducing housing problems. The interventions were found to have a small – but significant – positive effect on occupants' health. Similar positive effects were found for sub-groups of the population, with only minor differences. They conclude that the "potential health benefits [are] inherent in improving energy efficiency" (p.590; Maidment et al., 2014). The effect was slightly greater for low income households, children and people in poor health, the most vulnerable groups. An earlier review paper by Liddell and Morris (2010) provides further insight into the specific health improvements found in response to reductions in cold and damp housing. The authors reviewed five core housing intervention studies conducted between 2000 and 2009 in the United Kingdom, New Zealand, and USA. Importantly, the review suggests that it can be difficult to detect improvements in physical health. For most studies in this review self-reported health improved, but other clinical health indicators (e.g. General practitioner (GP) visits, the occurrence of colds) did not show any changes. Liddell and Morris (2010) suggest that physical effects may take longer to emerge. Interestingly, positive effects tended to be more pronounced for mental health and well-being – this led the authors to suggest that mental health improvements may acts as a 'catalyst' for improvements in physical health. The next section will discuss the proposed association between poor housing, mental health and well-being. Evaluating large housing interventions is ultimately a key method to investigate these associations, but opportunities for these types of studies are limited, and crucial insights are also gained from cross-sectional surveys.

1.2. The Effect of Cold and Damp Housing on Mental Health and Well-Being

The majority of studies in this area of research have focused on physical health. Only recently have empirical studies emerged that examine effects on mental health and well-being. Positive mental well-being or mental health is defined as "*a state of well-being in which the individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community*" (WHO, 2014). The absence of positive mental well-being does not imply the presence of mental disorder; people can already be at risk of poor outcomes if their mental health is unusually low without

experiencing mental disorders such as anxiety or depression (Campion et al., 2012). In fact, cold and damp housing are found to relate more strongly with reduced quality of life rather than mental disorder, so measures of mental well-being are thought to be particularly relevant in this context (Liddell and Guiney, 2015).

Research has shown that maintaining a warm home is seen by many householders as a basic need (Harrington et al., 2005). Not being able to fulfil this basic need, and experiencing a cold house, can have a negative effect on mental health and well-being. A wide range of mental health issues have been associated with living in a cold or damp home, including: persistent worries about energy bills (Anderson et al., 2012), concern about physical health (Tod et al., 2012), higher levels of depression and worry (Khanom, 2000), and chronic thermal discomfort (Gilbertson et al., 2012; see Liddell and Guiney, 2015 for a full summary of well-being outcomes). Liddell and Morris (2010) suggest that stressors linking to mental health are often associated with the affordability of solutions to housing problems. For instance, this includes the affordability of solutions such as heating the home to a comfortable degree, or installing necessary insulation improvements. Affordability is a key concern and one that will be discussed further in Section 1.3.

Liddell and Guiney (2015) reviewed nine intervention studies which assessed the impact of heating and insulation improvements on well-being. They conclude that the relationship between installing energy efficiency measures and improved well-being is 'moderately strong'. In their earlier research, health and well-being effects were found to be stronger for infants and children, thus they may be especially sensitive to fuel poverty (Liddell and Morris, 2010). Furthermore, in a longitudinal study by Pevalin et al. (2008) changes in housing problems were particularly found to affect mental health in men. Interestingly, on the other hand changes in housing problems influenced reported health problems in men and women – with the strongest effects found for women.

1.3. Establishing Complex Relationships: The Role of Affordability Concerns

The relationship between housing conditions, health and well-being is complex, and it is difficult to assign causal relationships as many factors interact with each other. As noted by Hopton and Hunt (1996): *"The issue of confounding variables which cluster together is one of the major methodological problems facing researchers in the field of social inequalities and health"* (p.56). For instance, housing problems may lead to poor health, but individuals in poor health may also be more likely to live in poor quality housing (e.g. due to unemployment).

In addition, the occurrence of cold and damp housing is closely related, so their individual effects are difficult to disentangle. Hopton and Hunt (1996) examined the effect of damp and cold housing on health and well-being in a sample of householders from a local authority

housing estate. Experiences with damp, rather than cold, were found to be an independent predictor of reduced well-being. But, in a large scale general population survey, Evans et al. (2000) found a stronger relationship between health and cold housing compared to health and damp housing. The effect of cold housing on health exceeded that of health-related lifestyles (e.g. smoking). In sum, findings are inconsistent to date.

Other complexities include the effect of neighbourhood factors. Scholars have noted factors which reduce housing problems, such as housing improvements or moving house, could also lead to other changes that may affect health, such as changes in neighbourhood conditions and socio-economic status (Pevalin et al., 2008). Research has shown that aesthetic improvements to the neighbourhood are a highly valued outcome of energy efficiency schemes, as reported by residents (Scott et al., 2014). However, housing improvements have been found to have an independent effect on well-being, separate from an effect of neighbourhood renewal (e.g. increased perceived neighbourhood quality and safety; Bond et al., 2012). This aligns with previous research by Poortinga et al. (2008). In this study factors influencing the relationship between neighbourhood deprivation and health were investigated. The relationship could be explained in part by socio-economic status, but Poortinga et al. (2008) emphasize the important role of contextual factors. The study showed that both neighbourhood perception (e.g. neighbourhood quality, disorder) and housing problems related to the relationship between neighbourhood deprivation and health.

To account for these complexities and interactions between the factors affecting health, well-being and housing, Liddell and Guiney (2015) have proposed a Multiple Pathway Model. The model is based on the assumption that living in a damp and cold home is a source of cumulative stress and thus presents an accumulation of stressors from multiple sources which, when combined, increase vulnerability to poor health and reduced well-being exponentially (Liddell and Guiney, 2015). The model suggests that the combined effect of living in a cold and damp home and having heating needs that are not affordable, directly triggers physical health problems and stress, along with a cycle of stress, anxiety and mood distortions. This can further deteriorate physical health which feeds into the stress cycle again. In turn, further financial worries are triggered through disability, unemployment, medical costs, and/or health-risk behaviours which affect the affordability of heating again.

There is an important role in this model for financial concerns, and indeed worries about work and money have been identified as important independent predictors of ill health, in addition to housing problems (Evans et al., 2000). Anderson et al. (2012) attempt to explain the specific financial burden brought upon by fuel bills, especially for low income households. The authors state that a common coping strategy for low income households to make ends meet is to

cut back on expenditure, mostly involving food and heating. Whereas cutting back on food expenditure without going hungry can be managed by reducing range and quality, cutting back on heating without feeling cold is seen by many householders as a less flexible process. Fuel bills are perceived as 'intractable', difficult to manage and change, and therefore often present a significant financial burden. As already touched upon in the previous section, the important role of perceived financial strain in predicting health and well-being was also highlighted by Liddell and Morris (2010). In their aforementioned review of intervention studies on health it was found that if heating becomes more affordable this could reduce stress about money and debt which is suggested in the review as an important route to improved mental health and well-being. The emphasis on *perceived* financial strain is important here as actual costs may increase after home improvements have been made – but householders experience greater value for money and perceived control over home heating.

1.4. The Current Research

There is a need for studies investigating the underlying pathways linking reductions in cold and damp housing to improved health and well-being, so targeted intervention strategies can be developed (Liddell and Guiney, 2015). Even though there is relatively consistent evidence for the relationship between energy efficiency improvements and health, the conditions under which this association occurs are less well established. Given the complexity of the issues, it is important to understand the relationship between housing problems and the process by which these problems relate to health and well-being. A survey, collecting both qualitative, open-ended responses, and quantitative responses (using numerical ratings), was conducted with a sample of social housing residents in South-West England. The UK is a relevant case study as it has one of the highest rates of fuel poverty in Europe, and rates continue to rise: the percentage of the UK population struggling to keep their home adequately warm increased from 5.7% in 2013 to 10.6% in 2015 (Pittini et al., 2015).

In this study the Multiple Pathway Model (Liddell and Guiney, 2015) provides a framework for examining householders' experiences of living in cold and damp homes, and the relationship between poor housing and health and well-being. This research takes a two-part approach and poses the following research questions (RQs):

RQ 1: Relationship between cold housing and problems with condensation, damp and mould. The Multiple Pathway Model discussed the combined effect of cold and damp housing. Previous research has shown that the occurrence of cold and damp housing is often related (Healy and Clinch, 2004; Sharpe et al., 2015a). This study adds to our understanding of this relationship, and provides further insight into the type of problems low income households are

likely to experience in three ways. 1) This study investigates whether there are differences in the specific type and location of self-reported housing problems experienced by householders who say they can versus cannot keep their home comfortably warm. 2) Given that 'affordable warmth' is an important factor in influencing health issues resulting from poor housing (Pevalin et al., 2008), this study not only compares households who can and cannot keep comfortably warm. It also includes a third group: those households who say they can keep warm but with a qualification: they say it costs them a lot to keep warm. 3) A mixed method approach was used to assess these questions. The quantitative rating data captures the housing problems reported by households and allows us to test the relationships between these problems. In addition the qualitative responses provides deeper insight into the wider context in which these problems occur.

RQ 2: Relationship between housing problems, health, well-being and affordability.

Energy affordability concerns are central to the Multiple Pathway Model; the model suggests that experiencing a combination of housing problems and concerns regarding the affordability of energy triggers poor health and stress. This brings forward the intriguing question whether cold housing and other housing problems such as condensation, damp and mould, still trigger poor health and reduced well-being if affordability concerns are controlled for. In other words, is there a direct relationship between housing problems and poor health and reduced well-being, or an indirect relationship via energy affordability concerns? (see Figure 1). The current study examines this question through a series of mediation analyses. Mediation can explain the process by which one variable affects another. Specifically it considers how a third variable (in this case: affordability concerns) affects the relationship between two other variables (in this case: housing problems and health/well-being; MacKinnon et al., 2007). Given findings from previous research, discussed in Section 1.2., which indicate a potential gender effect on the association between housing problems and health/well-being the effect of gender on the relationships in the mediation model is also explored.

2. Method

2.1. Participants and Procedure

As part of the first phase of the multi-disciplinary EnerGAware research project (EnerGAware, 2016) a large tenant survey was administered to capture responses from social housing residents in a city in South-West England. A self-report, paper-based survey, accompanied by a letter, a one-page flyer about the project and a pre-paid return envelope was sent by post to 2,772 households. The letter invited households to either complete the paper-based survey and return it in the pre-paid returning envelope or undertake the survey online. A prize draw (for

family days out and shopping vouchers) was used as an incentive to encourage households to complete and return the survey. After two weeks, a further letter was sent out to remind households to complete the survey. In total, 536 (503 paper-based and 33 online) of the households completed the survey, giving an overall response rate of 19.3%. Table 1 provides an overview of the demographics. The majority of respondents were 45 years or older and female. Retired or in employment made up the two biggest categories, and nearly half reported being in receipt of welfare benefits, and considered themselves, or another member of their household, to have a disability.

2.2. Materials

2.2.1. Perceived problems with condensation, damp, or mould (CDM)

A range of items were included to assess problems with condensation, damp or mould (CDM). First, respondents were asked to respond with a yes/no answer to the question: do you have any problems with condensation, damp or mould in your home? Second, respondents were asked in which rooms problems with CDM occur; respondents could select more than one answer from the following: living room, main bedroom, hall, kitchen, bathroom, other bedrooms. The number of rooms in which each respondent reported experiencing CDM problems was added up and this score was used for analysis. Third, items were included to assess the type of problems that householders experienced in two of the main rooms in their home: the living room and main bedroom as this is where householders spend most time. For each room, respondents were asked to indicate if they had any of the following issues: 1) steamed up windows; 2) steamed up/wet walls; 3) mildew/rot/mould on window frames; 4) stains/rot/mould on walls or ceilings; 5) stains/rot/mould on floors, carpets or furniture; 6) other problems with condensation, damp or mould. The number of CDM problems each respondent reported experiencing for the living room and main bedroom was added up separately. For instance, if a respondent indicated experiencing a) steamed up windows, b) stains/rot/mould on floors, carpets or furniture, and c) steamed up/wet walls in their living room the value of the living room variable would be 3. Fourth, respondents were asked to rate on a four-point scale, ranging from 1 (A great deal) to 4 (Not at all), how much the issues with CDM affected them. Respondents could also select a 'don't know' box. Finally, in an open question, respondents were asked if there were any other energy issues with their home that they would like to tell us about.

2.2.2. Keeping comfortably warm

One item was included to assess the problems householders experienced with keeping their home comfortably warm. Respondents were asked the following question: 'During the cold winter weather, can you normally keep comfortably warm in your living room?'. The response

options were yes; yes, but it costs a lot; no; don't know; not applicable. The second category was included to capture those households who might be able to keep warm but it costs them a lot to do so. The item focused specifically on the living room as this is where householders spend the majority of their awake time engaging mostly in sedentary behaviours, and as such it may be more difficult to keep comfortably warm.

2.2.3. Perceived affordability of energy

To assess the perceived affordability of energy, respondents were asked to rate on a five-point scale, ranging from 1(very easy) to 5(very difficult), 'How easy or difficult it is for you to afford your energy bills?'. Respondents could also select a 'don't know' box.

2.2.3. Health and well-being

General health was measured by asking respondents to answer the question 'How was your health in general in the last 12 months' using a five-point scale ranging from 1(very good) to 5(very bad). This measure was based on the item used by the Office for National Statistics in the UK (ONS, 2016), and similar measures have been used in previous research on housing and health (e.g. Poortinga et al., 2008). Based on an item commonly included in the Personal Well-Being Index (International Wellbeing Group, 2013), well-being was measured by asking respondents to answer the question 'Overall, how satisfied are you with life nowadays?', using a eleven-point scale ranging from 0(not at all satisfied) to 10(completely satisfied). Self-rated health is thought to be a good indicator of overall health (Idler and Benyamini, 1997; Strawbridge and Wallhagen, 1999; Burström and Fredlund, 2001; Franks et al., 2003; Kawada, 2003).

2.3. Data Analysis

A number of items included 'don't know' or 'not applicable' response options. In addition, some respondents did not provide answers to all the items in the survey. As a result the number of valid cases for each analysis varies. Unless stated otherwise, missing, don't know and not applicable responses were excluded from the analysis. The quantitative data was analysed using Chi-Square tests (to assess relationships between categorical variables), and non-parametric Mann-Whitney U tests (when the dependent variable was not normally distributed). The qualitative data (see Section 2.2.1.) was analysed using content and exploratory thematic analyses. One hundred and forty-four open-ended responses were collected, from these, 105 responses involved issues with temperature or CDM. A content analysis was conducted on these 105 responses, this involved placing the responses into categories based on the type of issues that were reported. Afterwards, an exploratory thematic analysis was conducted to identify overarching themes in the responses.

2.3.1. Mediation analyses

To examine whether the relationship between housing problems and health and well-being was mediated by affordability concerns a series of regression analyses were conducted following the steps set out by Baron and Kenny (1986; see also MacKinnon et al., 2007). These regression analyses test whether there is: 1) a significant relationship between housing problems (i.e. the independent variable) and health/well-being (i.e. the dependent variables); 2) a significant relationship between housing problems and energy affordability concerns (i.e. the mediator variable); 3) a significant relationship between energy affordability concerns and health/well-being when controlling for the influence of housing problems; 4) a significant relationship between housing problems and health/well-being, when controlling for the influence of affordability concerns. Following the literature, if the relationship between the independent and dependent variable (Step 1) is weakened or no longer significant when controlling for the influence of the mediator variable (Step 4) there is a partial mediation effect. The size of the indirect effect was calculated using a bootstrapping procedure developed by Hayes and colleagues (Hayes, 2013; Preacher & Hayes, 2004). The regression coefficients in the models provide information on the direction of the effects (see Section 3.3.).

3. Results

3.1. Perceived problems with Keeping Warm, Condensation, Damp or Mould

Nearly half of the respondents reported being able to keep comfortably warm in their living room during the cold winter weather (48.9%), another 36.2% answered they could keep warm but it costs a lot. A smaller group of respondents (11.9%) could not keep comfortably warm in winter. Finally, a small minority did not know whether they could keep warm (2.2%), did not provide an answer to this question (0.4%), or indicated that the question was not applicable to them (0.4%).

With regards to CDM problems, 41.7% of the respondents reported experiencing problems with CDM, 54.7% reported no problems with CDM and 3.5% did not provide an answer to this question. Figures 2 and 3 focus on those householders who reported experiencing problems with CDM (N = 224). As can be seen in Figure 2, problems with CDM were mainly reported for the main bedroom and bathroom. On average, householders reported experiencing problems in two rooms in their house (Median = 2).

Figure 3 shows that, for both the living room and main bedroom, respondents mainly reported problems with the windows and/or window frames, although mould on the walls or ceilings was also a common issue. On average, householders experiencing CDM problems reported one problem in the living room (Median = 1) and one in the main bedroom (Median = 1). Finally, respondents who indicated that they experienced problems with CDM reported that

this affected them a fair amount on a scale ranging from 1 (A great deal) to 4 (Not at all), (M = 2.13, SD = 0.90).

3.1.1. Relationship between keeping warm and problems with CDM

Excluding missing and 'don't know' responses, a significant relationship was found between keeping warm and CDM issues, χ^2 (df = 2) = 48.20, p<.001. The majority of respondents who reported that they could not keep their living room comfortably warm in winter also reported experiencing problems with CDM (70%), whereas around half of the respondents for whom keeping warm costs a lot also experienced problems with CDM (52%), and just over a quarter of respondents who had no problems keeping warm also experienced problems with CDM (28%; see Figure 4). Figure 5 focuses only on those householders who reported experiencing CDM, it shows the specific CDM problems householders experienced in their living room, broken down by whether they could keep their living room comfortably warm. Rather than a clear association between one (or more) CDM problems and keeping warm, Figure 5 suggests that there was a cluster of problems; all issues were more common when householders could not keep their living room comfortably warm, or when it costs them a lot to do so.

The findings so far suggest that householders who experienced problems with keeping their living room comfortably warm – in terms of feeling cold or finding that it costs a lot to keep warm -also reported a wide variety of CDM problems compared to householders who did not report issues with keeping warm. These differences are supported by the results displayed in Table 2, where the three categories are compared in more depth. A stepwise relationship was found between the extent to which householders could keep their living room comfortably warm and CDM problems. Householders who could not keep their living room comfortably warm reported the highest number of rooms with CDM problems, as well as most CDM problems (in their living room and main bedroom) followed by householders for whom keeping warm costs a lot, and finally householders who did not report problems keeping warm. Respondents who could not keep their living room comfortably warm in winter, or for whom it cost a lot, also indicated that the CDM problems affected them to a larger extent compared to respondents who could keep their living room comfortably warm, without cost qualification (see Table 2).

3.1.2. Qualitative responses

An open question gave respondents the opportunity to share more information about the energy issues they experienced. These responses were used to gain further insight into the type of housing problems present in this sample and, especially, how these were experienced by householders. In total, one hundred and five responses discussed issues with temperature or CDM and eight categories could be identified within these responses. The results are summarised in Table 3. The table shows that the majority of the reported issues (85%)

concerned the temperature or thermal comfort of the home. This included lack of insulation and experience of draughts (35%), lack of or insufficient heating (30%), cold (16%), or overheating (4%). The numbers in the table do not add up to the total number of responses, as many respondents mentioned multiple issues. Another 30% of respondents elaborated on issues with CDM.

In line with the quantitative results discussed in the previous section, the qualitative responses further highlight the interaction between issues with CDM and keeping warm: out of the 31 responses dealing with CDM, eight responses also discussed issues with cold, heating and/or lack of insulation. In particular, the responses illustrate householders' quite sophisticated attempts to make sense of the complex interaction between insulation, heating and ventilation, as illustrated by the following quote:

> *"We have no window in the bathroom, and just have an extractor fan, which when switched on and bathroom door closed does very little to remove the steam from the shower if any at all. Then when we open the bathroom door all the steam escapes into the landing and the two bedrooms thus creating mould. The windows in the bedrooms are on the vents all year round. So you can imagine in the winter before the heating comes on that it can get quite cold. I am forever buying mould and mildew removers to get the mildew off the walls, windows and ceilings in the bedrooms. […] I cannot have the bathroom door open in the winter and the steam sets off the smoke alarm on the landing".*

This response illustrates the complexity of the issues that respondents experience and how some householders have considered the situation in depth. Rather than experiencing one problem with one cause, the responses highlight how different housing problems interact. For instance, in the quote below a householder describes how lack of insulation leads to various problems, the use of a fan might offer a solution but the householder is worried about the energy use associated with it:

> *"There is insufficient ventilation in the bathroom. There is a window but it does not open, so mould grows quickly on the tiles and shower lead and the glass get[s] really steamed up which leaves everything damp. There is a fan but this does not really work and uses more electricity than any of the appliances"*

Another theme that emerges from many responses (see Table 3 and below) is a sense of frustration or helplessness that householders seem to experience with regards to these housing problems, and also the use of inferential reasoning in the last example:

> *"Draughty windows hard to keep heat in, tried everything"*
> *"..damp and condensation in all my rooms, I cannot open any windows in any rooms"*
> *"Front room window leaks when we have heavy rain, has been investigated several times with no joy. Therefore, if rain can get in, surely heat can get out!"*

Some respondents specifically mentioned experiencing stress or worry with regards to issues in their home (see 'Health/well-being effects' in Table 3). These responses again illustrate a feeling of helplessness, and of not being able to do anything about the problem; one respondent specifically related his/her housing problems with an existing health condition:

> *"Myself and my oldest son both have asthma and damp or mould would cause major issues with our health conditions. The damp in the bathroom is only a small amount above the toilet but is has already cause[d] my son's asthma to become worse"*

This relationship between housing problems and health, and specifically what may underlie this relationship are explored in the next section.

3.3. Relationship between Housing problems, Health and Well-Being: The Role of Affordability Concerns

The mediation analyses in this section test whether there is a direct relationship between housing problems and health and well-being, or whether housing problems relate to an increase in concerns about the affordability of energy which in turn have a negative effect on health and well-being. Stated otherwise, these analyses help to answer the question whether housing problems still relate to reduced health and well-being when controlling for affordability concerns. Four mediation analyses were conducted examining the relationship between: 1) keeping warm, energy affordability, and well-being 2) keeping warm, energy affordability, and health, 3) CDM problems, energy affordability, and well-being, and finally 4) CDM problems, energy affordability, and health.

3.3.1. Keeping warm, affordability and well-being

For the analyses in this section and Section 3.3.2., a mediation procedure with a multi-categorical independent variable was used, as the item measuring whether respondents could keep their living room comfortably warm in winter had three response options (for further

details see Hayes and Preacher, 2014). Simply stated, in the mediation model (see Figure 6 and 7) the independent variable was split into two categories:

D1 comparing respondents for whom it costs a lot to keep warm with respondents who indicated having no problems keeping comfortably warm.

D2 comparing respondents who could not keep comfortably warm with respondents who indicated having no problems keeping comfortably warm.

Affordability concerns partially mediated the relationship between keeping warm and well-being. The arrows in Figure 6 indicate the following relationships:

Arrows 1 and 2: First, the relationship between keeping warm and well-being was examined (Step 1 in Section 2.3.1). Householders who could not keep their living room comfortably warm, or for whom it cost a lot, reported feeling less satisfied with life overall. For the top arrow (D1) a score of 1 equalled being able to keep the living room comfortably warm but finding it costs a lot, a score of 0 equalled no problems with keeping the living room comfortably warm. So, the negative association indicates that when it costs a lot to keep the living room comfortably warm, householders reported feeling less satisfied with life overall (b = -1.32, t = -5.21, p<.001). For the bottom arrow (D2) a score of 1 equalled not being able to keep the living room comfortably warm, and a score of 0 again equalled no problems with keeping warm. So, the negative association suggests that not being able to keep the living room comfortably warm was related to feeling less satisfied with life overall (b = -1.87, t = -5.00, p<.001).

Arrows 3 and 4: Second, the relationship between keeping warm and affordability concerns was examined (Step 2 in section 2.3.1). Householders who could not keep their living room comfortably warm (Arrow 4; b = 0.96, t = 7.04, p<.001), or for whom it costs a lot (Arrow 3; b = 0.81, t = 8.66, p <.001), perceived more difficulty in affording their energy bill.

Arrow 5: Third, the relationship between affordability concerns and well-being (Step 3 in Section 2.3.1) was examined. An increase in affordability concerns was associated with feeling less satisfied with life overall (b = -0.53, t = 4.32, p <.001).

Finally, the relationship between keeping warm and well-being was examined, controlling for affordability concerns (Step 4 in Section 2.3.1). The relationship between keeping the living room warm but finding it costs a lot (D1) and negative well-being reduced somewhat in strength when controlling for affordability concerns about the energy bill (Arrow 1; b = -0.89, t = -3.32, p = .001). Thus, next to the direct relationship between keeping warm and well-being, there was also an indirect relationship via affordability concerns (Indirect effect: -0.43, 95%CI [-.69;-.23]). As zero is not in the confidence interval (i.e. it ranges from -.69 to -.23), the indirect

effect is significantly different from zero. The relationship between not being able to keep comfortably warm (D2) and negative well-being did not reduce in strength when controlling for affordability concerns (Arrow 2; b = -1.35, t = -3.50, p <.001), so in this case the relationship between keeping warm and reduced well-being could not be explained by an increase in affordability concerns.

3.3.2. Keeping warm, affordability and health

As can be seen in Figure 7, affordability concerns partially mediated the relationship between keeping warm and general health. Similar to the relationships found with well-being, not being able to keep comfortably warm (Arrow 2; b = 0.59, t = 3.48, p<.001), or if it costs a lot to do so (Arrow 1; b = 0.42, t = 3.69; p<.001), was associated with poorer health. Both relationships reduced in strength when controlling for affordability concerns, to the extent that they were no longer statistically significant (Arrow 1; b = 0.18, t = 1.52, p = .130; Arrow 2; b = 0.30, t = 1.75, p = .080). Therefore, the results suggest that struggling to keep comfortably warm at home was associated with affordability concerns about energy bills; these concerns in turn were related to poor general health. This supports an indirect effect from problems with keeping warm upon general health via affordability concerns (Indirect effect D1: .24, 95% CI [.15;.36]; Indirect effect D2: .28, 95% CI [.17;.45]). Of particular note here, is that when comparing Figure 6 and 7, the relationship between keeping warm and well-being is stronger than the relationship between keeping warm and general health.

3.3.3. CDM problems, affordability and well-being

The results indicate that affordability concerns partially mediated the relationship between experiencing problems with CDM and well-being (see Figure 8):

Arrow 1: First, the relationship between CDM problems and well-being was examined (Step 1 in Section 2.3.1). Problems with CDM were positively associated with well-being (b = 0.54, t = 2.22, p = .027). A score of 1 equalled 'problems with CDM' and a score of 2 equalled 'no CDM problems', so this positive relationship indicates that experiencing CDM problems was associated with feeling less satisfied with life overall.

Arrow 2: Second, the relationship between CDM problems and affordability concerns was examined (Step 2 in Section 2.3.1). The left arrow in Figure 8 indicates that problems with CDM were negatively related to affordability concerns (b = -0.44, t = -4.70, p<.001). That is: householders who experienced problems with CDM reported more difficulty with affording their energy bill.

Arrow 3: Third, the relationship between affordability concerns and well-being was examined (Step 3 in Section 2.3.1). As the right arrow in Figure 8 indicates, if householders reported more difficulty with affording their energy bill they felt less satisfied with life overall (b = -0.69, t = -5.80, p<.001).

Finally, the relationship between CDM problems and well-being was examined, when controlling for affordability concerns (Step 4 in Section 2.3.1). The relationship between experiencing CDM problems and well-being was no longer significant when adjusted for affordability concerns (b = 0.24, t = 1.00, p = .316). So, affordability concerns mediated the relationship between CDM problems and well-being: experiencing CDM problems related more strongly to reduced well-being if accompanied by concerns about the affordability of energy (Indirect effect: 0.30, 95% CI[.15;51]).

3.3.4. CDM problems, affordability and health

A similar mediation effect was found with regards to general health, as can be seen in Figure 9. Although weaker than the relationship found for well-being, experiencing CDM problems was (marginally) related to reporting poorer health (b = -0.21, t = -1.89, p =.060). This relationship reduced in strength when controlling for affordability concerns (b = -0.06, t = -0.57, p = .566). Thus, a significant indirect relationship to general health was found: householders experiencing problems which CDM also reported more difficulty with affording their energy bill, these concerns in turn, had a negative impact on general health (Indirect effect: -0.15, 95%[-.23; -.08]).

3.3.5. Gender effects

To examine potential gender effects, the four mediation analyses were conducted for male and female respondents separately. Overall, the effects tended to be more consistent and stronger for male respondents (for further details on these analyses see Appendix A). The link between housing problems (especially CDM issues), and well-being and general health were stronger for male, compared to female respondents. Furthermore, the mediation effect of affordability concerns was more consistently found for male respondents.

4. Discussion

This paper studied the experience of living in cold and damp housing on social housing residents. First, the study investigated the association between cold and damp housing conditions. In line with previous research (Healy and Clinch, 2004; Sharpe et al., 2015a) experiencing problems with keeping the living room comfortably warm in winter was related to more problems with CDM. The current study showed that keeping warm was not necessarily found to relate to one, or several particular problems. Instead, it was found that individuals struggling to keep their living room comfortably warm in winter reported a cluster of CDM problems in multiple rooms in their house, compared to individuals who did not experience problems with keeping warm. Further extending previous research, the study not only examined the relationship between cold and damp housing, but also explored the relationship between (a lack of) affordable warmth and CDM problems. A stepwise effect was found: households who could not keep their living room comfortably warm in winter reported the

highest number of rooms with, and the highest variety of, CDM problems, followed by households who can keep warm but it costed them a lot to do so, and finally households who did not experience problems keeping warm. A number of reasons could explain this effect. For instance, householders who find that it costs a lot to keep warm might be less likely to open windows to ventilate the house as they want to keep the heat in – thus, creating more potential for CDM problems to occur. The qualitative responses highlighted the struggles social housing residents faced when trying to ventilate and heat their home effectively within the context of building and financial constraints. They illustrated the complex interactions people were observing and how hard some of them were trying to understand the relationships between cold and damp housing conditions. These quotes also put forward a sense of frustration and helplessness about not being able to find a solution to damp and cold housing problems.

Second, the study examined the relationship between housing problems and health and well-being, specifically focusing on the role of affordability concerns. In support of previous findings, the results showed that both struggling to keep warm in winter and problems with CDM related to poor health and reduced well-being. With regards to keeping warm, it is worth highlighting here that not only did cold housing conditions relate to poor health and reduced well-being, but a similar relationship was found for householders who indicated that they could keep warm but it costs them a lot to do so. Furthermore, in line with findings reported by Liddell and Morris (2010), the relationships between housing problems and well-being tended to be stronger compared to the relationships between housing problems and general health. Moreover, the ability to keep warm at home, compared to experiencing problems with CDM, related more strongly to health and well-being (Evans et al., 2000). Extending previous research, the study explored what may underlie housing problems affecting health and well-being. That is, the study examined whether the perceived affordability of energy bills mediated this relationship. As suggested in the Multiple Pathway Model (Liddell and Guiney, 2015) it was found that the combination of housing problems and affordability concerns related to poor health and reduced well-being. Rather than a direct effect of housing problems upon negative health impacts, support was found for an indirect effect: householders who experienced housing problems were more likely to express difficulty with affording their energy bill, these affordability concerns in turn were associated with reporting poor general health and reduced well-being.

This mediation effect of affordability concerns was found for both types of housing problems assessed in this study, although the effect was slightly less straightforward for the link between keeping comfortably warm and well-being. Being able to keep warm but finding that it costs a lot to do so (compared to not being able to keep warm), related to reduced well-being. This relationship reduced in strength when controlled for affordability concerns regarding

energy bills, but it remained strongly significant. Also, for householders who could not keep comfortably warm, the relationship with reduced well-being remained strong after controlling for affordability concerns. So, when it comes to the question whether respondents who are unable to keep their house warm, or for whom it costs a lot to do so, report reduced well-being because of accompanying concerns regarding the affordability of their energy bills, the answer is: in part. That is, when compared to the other mediation effects reported here the extent to which affordability concerns can account for the relationship between keeping warm and well-being is lower. Thus, one suggestion could be that struggling to keep warm also has a (strong) direct effect on well-being rather than an indirect effect via affordability concerns regarding energy bills – or this relationship is mediated by factor(s) not captured in the present research.

Additionally, previous research has found a stronger relationship between changes in housing problems and mental health for men compared to women, while changes in reported health problems were particularly strong for women (Pevalin et al., 2008). This finding was not fully replicated in the current study, here relationships were stronger for male respondents with regards to well-being as well as general health – especially when studying relationships with CDM problems. The proposed mediation effect was also more consistently found for male respondents.

Regarding the findings from the mediation analyses, it is important to take into account that one variable is unlikely to fully explain the relationship between two other variables (MacKinnon et al., 2007), especially ones as complex as housing problems and health. However, the results do point towards a key role for affordability concerns in the relationship between poor housing conditions, poor health and reduced well-being. The health and well-being impacts of cold and damp housing can be explained (partly) by associated concerns regarding the affordability of energy bills. Therefore, the research suggests that, in line with the Multiple Pathway Model (Liddell and Guiney, 2015), it is the combined effect of housing problems and difficulties with the affordability of energy bills which is particularly detrimental for health and well-being.

4.1. Limitations and Future Research

Before going into the wider implications of these findings it is important to discuss some factors to take into account when interpreting the results. First, single-item measures were used to assess the majority of the variables included in this study. There is mixed support for the use and validity of single-item measures (Bergkvist and Rossiter, 2007; Gardner et al., 1998). However, within this context it was important to keep the survey short and simple to encourage as many householders as possible to respond. Moreover, we relied on health indicators commonly used in very large studies, e.g., by the UK's Office of National Statistics. Second, the

item measuring whether householders were able to keep their home comfortably warm warrants some further discussion. The additional category 'yes, but it costs a lot' was added to capture the full range of 'affordable warmth' as discussed in the Section 1.4. Some interesting differences were found between the 'no' and 'yes, but it costs a lot' category with respect to their relationships with health and the mediating effect of affordability concerns. Importantly, at least in this sample of social housing residents, being able to keep warm but it costing a lot was more common than not being able to keep comfortably warm. This group may not have been captured with a simple yes/no response option. However, we are aware that there might be some overlap between these categories, and this needs to be considered when interpreting the results. Future research could consider using multiple items to capture the different aspects of affordable warmth even more clearly.

A third point to consider is the issue of causality – this was a cross-sectional study and, as such, it is descriptive of one point in time. As was discussed in the Introduction, people in poor health may also be more likely to live in low quality housing due to, for instance, unemployment. The mediation analyses provide an insight into the relationships between the variables, but they are not a means to establish causality (MacKinnon et al., 2007). The directions of the effects need to be based on theoretical grounds, rather than focusing merely on the statistical effects. In this case, previous research has supported a causal relationship between housing problems and health using before/after designs (cf. Maidment et al., 2014). With regards to affordability concerns it should be noted that although in our model an increase in housing problems was associated with an increase in affordability concerns, this does not imply that the relationship could not go in the other direction as well. Indeed, Liddell and Guiney (2015) propose both relationships in their Multiple Pathway Model. The relationship between housing conditions and health is complex and multidimensional, and the results should be interpreted with this in mind. Longitudinal studies could provide further evidence on the role of affordability concerns in the relationship between housing problems and health. Moreover, the model and our research suggest a potential role for community interventions that focus on financial concerns directly. A thorough evaluation of such approaches could provide much stronger data on the causal pathways between housing conditions, money worries and health and well-being.

4.2 Conclusions and Policy Implications

Given the apparent central role of affordability concerns in the relationship between housing conditions and health, this research suggests that low income households will be particularly vulnerable to the impact of housing problems. This is in line with previous studies, which have shown that the health impacts of improving energy efficiency are especially positive for individuals in low income households (Maidment et al., 2014). Next to improving the energy

efficiency of houses and thereby reducing housing problems, other approaches could be taken to reduce the negative health impacts of housing problems and affordability concerns. In fact, a combined approach of technical improvements and household support might be needed to maximise health improvements. Potential 'side effects' of interventions should also be considered. In a recent study, better energy efficiency was associated with poorer health (Sharpe et al., 2015c). In this study with social housing residents, increased energy efficiency was related to increased risk of current asthma, even though the presence of mould was reduced. This was thought to result from poor ventilation and insufficient heating behaviours combined with other risk factors (e.g. housing characteristics). This finding highlights again the complex interaction between health, behaviour and the built environment and suggests that technical measures to improve energy efficiency should be integrated with a behavioural intervention programme as well as being informed by the wider context and concerns of the householders targeted. As noted in the Introduction (Section 1.4), although there is relatively consistent evidence for the relationship between energy efficiency improvements and health effects, more insight is needed regarding the conditions under which this relationship occurs. Based on the current study three important considerations are put forward when thinking about the context in which energy efficiency improvements are offered to households and the support that is being offered in terms of managing energy use. First of all, when it comes to tackling housing problems and improving health and well-being a tailored approach, taking into account the idiosyncrasies of each household and the building they live in, may be more effective. The results showed that rather than a simple relationship between cold housing and a specific CDM issue, cold housing related to a mixture of problems. Furthermore, the qualitative data illustrated some of the building and financial constraints households come up against when trying to overcome this specific mixture of household problems, but also how carefully some of the householders considered these interrelated issues. An example of a personalised approach which may support more effective heating, ventilation and insulation practices is thermal imaging. Thermal images capture temperature differences by measuring infrared radiation from the surface of buildings (Pearson, 2011). This allows people to 'see' normally invisible heat flows in the home, providing insight into where heat is being lost or where cold air is coming into the home (Goodhew et al., 2015). This personal information can then be used by the householder to implement simple measures such as draughtproofing and insulation where required and adjust heating practices to keep warm more efficiently (Boomsma et al., 2016). It could also be used as a communication and engagement tool by housing associations. Thermal imaging can be integrated into a wider energy efficiency advice programme as illustrated in a recent guide published by the UK Department for Business, Energy and Industrial Strategy (2016). This brings us to the second important point to consider. As discussed in the

Introduction, one of the reasons why the financial costs related to energy, and heating in particular, are thought to be perceived as a burden on households is because they do not feel there is much flexibility with regard to their behaviour (Anderson et al., 2012). This is also reflected in the current study through the feelings of frustration and helplessness expressed in the qualitative responses. Educational and behavioural campaigns alongside energy efficiency improvements could be part of the solution, especially if they focus on providing behavioural strategies to help households make the most of technical improvements and reduce their energy bills, as well as helping individuals understand how their home uses and wastes energy. This could help householders regain a feeling of control over their home and reduce the 'inflexible burden' of fuel bills. A third point that is important to note here is that energy advice is often mainly aimed at reducing energy costs. Although this could help people make financial savings, it does not take into account the wider context of household energy use. As supported by the current study – energy use, financial concerns, housing problems, health and well-being are strongly interconnected, especially in low-income households. Encouraging people to reduce their energy consumption without considering the impact this could have on housing problems, health and well-being has only limited benefits for householders. The qualitative responses showed that in some cases householders knew that there might be a behavioural solution to their housing problems (e.g. turn on an extractor fan), but they were afraid to enact on it due to the associated financial costs. This reflects an important stressor affecting well-being, also mentioned by Liddell and Morris (2010), namely the affordability of solutions to housing problems. Therefore, when communicating about energy use, especially to people on low incomes, it is important to work on maintaining a balance between energy costs and a comfortable/healthy home. Examples exist of this integrated approach to energy advice. To illustrate, Cornwall Council in the UK runs the Winter Well-Being campaign (for details see Cornwall Council, 2017). This campaign offers vulnerable households who are in poor health or at risk of living in cold and damp conditions a range of services to ensure a warm and healthy home. This includes tailored energy advice (i.e. home visits), but also practical advice on reducing energy bills, condensation and damp, debt advice and health information.

In sum, this research attempted to unravel some of the complex relationships between housing problems, energy affordability concerns, and health and well-being in UK Social Housing using the Multiple Pathway Model as a framework. The study adds to previous research into the multi-facetted problem of fuel poverty. The findings show that there are a range of housing problems which social housing residents may be facing if they struggle to keep their home comfortably warm. These housing problems also have a negative impact on health and well-being, which can in part be explained by an increase in affordability concerns. Thus, providing

affordable warmth to low income households and reducing a feeling of helplessness with regards to energy bills using a tailored, integral approach may be key in reducing negative health and well-being impacts.

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Table 1

Demographic variables

Demographic variable	Mean and/or frequency
Age	*M* = 58 (*SD* = 17.27), ranging between 18-96: 10% Missing; 2% 18-24; 9% 25-34; 12% 35-44; 17% 45-54; 18% 55-64; 18% 65-74; 16% 75+
Gender	37% Male; 56% Female; 7% Missing
Employment status	38% Retired; 32% Employed; 9% Unemployed; 3% Seeking work; 1% Student; 19% Missing
Welfare benefits (e.g. unemployment allowance, housing benefits)	46% Yes; 42% No; 12% Missing
Disabilities	35% Yes; 14% Yes, another member of the household; 42% No

Table 2

Mean scores for the experience of CDM problems depending on whether respondents could keep comfortably warm in their living room during winter

	During the cold winter weather, can you normally keep comfortably warm in your living room?		
	Yes	Yes, but it costs a lot	No
Number of rooms with CDM problems	0.60(1.13)[a]	1.32(1.62)[b]	1.81(1.66)[c]
Number of CDM problems in the living room	0.32(0.84)[a]	0.78(1.20)[b]	1.16(1.55)[b]
Number of CDM problems in the bedroom	0.46(1.00)[a]	0.82(1.28)[b]	1.34(1.57)[c]
Experience CDM problems (affect)[l]	2.81(1.16)[a]	2.35(0.94)[b]	2.02(1.05)[c]

[l]Response scale ranging from 1 (A great deal) to 4 (Not at all).

Note: means that have no superscript in common are significantly different from each other ($p < .05$) based on a Mann-Whitney U analysis.

Table 3

Content analysis on qualitative responses

Reported issue	Sample quotes
Insufficient/ineffective insulation *N* = 37	"…window in lounge does not fit properly, loft needs insulating" "I have a draught under the front door" "I think my home needs better insulation. The loft needs doing, cavity wall insulation, and draught proofing around doors"
Insufficient/ineffective heating *N* = 31	"[I] would like more modern radiators installed as these would give out more heat and would therefore heat the bungalow quicker which in turn would use less gas" "No heating in kitchen or bathroom or back bedroom" "The radiators are single small units for the size of the house and in winter months are not very effective at all"
Condensation, damp or mould *N* = 31	"…a dehumidifier is running day and night" "I have been waiting for an inspection for the damp in the two bedrooms, its been looked at before and the job is not completed!" "When using bathroom, with air extractor on, window open – still get loads of condensation. I have painted and repainted and wipe ceiling constantly. Black mould everywhere."
Cold housing *N* = 17	"Kitchen very cold. (icy). Passage the same" "It gets cold in my living room in cold weather" "It's a very cold flat"
Insufficient/ineffective ventilation *N* = 9	"Need air vents" "The vent in the kitchen has caused wet/damp wall paint to peel"
General poor quality housing *N* = 7	"Windows that were installed by the builders were poorly installed" "The poor build quality by […] has led to much inconvenience"
Health/well-being effects *N* = 5	"The bathroom is very mouldy near the toilet. It has been checked and the mould removed, but as I cannot see I worry about the mould returning. I need a fan in the bathroom but I've been told that the walls are too narrow to fit one" "Damp in bathroom. Damp in back room. Was told condensation from a tumble dryer but I have never owned one. I am fed up of re-decorating and painting over mould and damp in my house. Its very depressing!!" "Last summer, although I had a fan in my bedroom going day and night, it was 30 degrees a lot and it made me feel distressed at night"
Overheating *N* = 4	"When the cooker is being used the front room temperature rises. It becomes really hot" "Excessive heating from underfloor heating"

Figure 1. Mediation effect between housing problems, affordability concerns, and health and well-being, examined in this research.

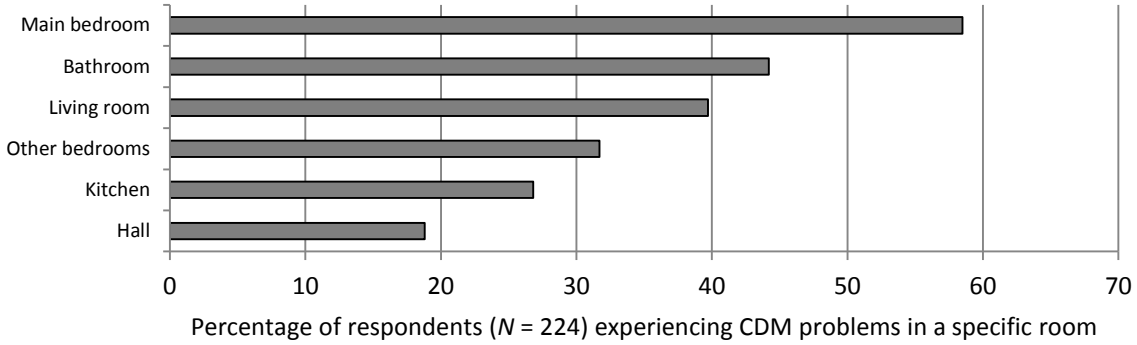

Figure 2. Responses to the item 'If you have issues with condensation, damp or mould, in which rooms does it occur?'.

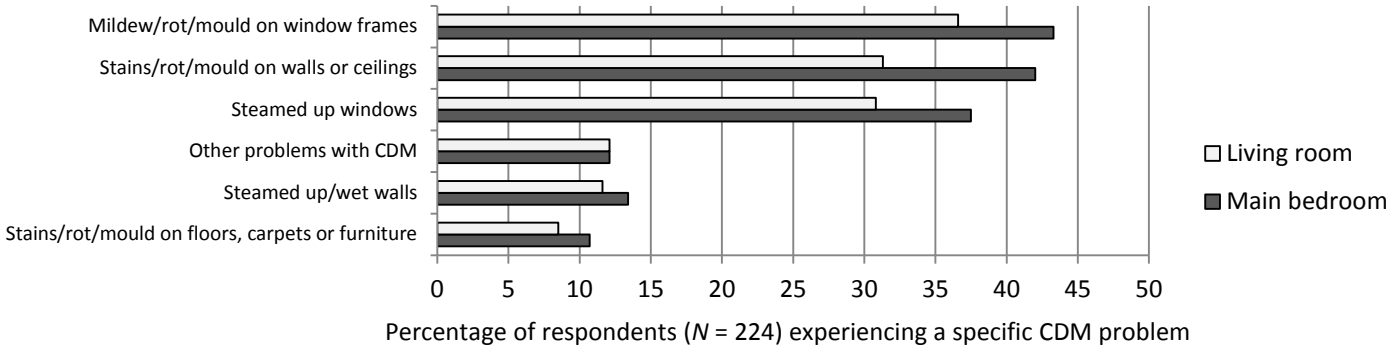

Figure 3. Responses to the items 'In your living room/main bedroom, do you have any of these issues?'.

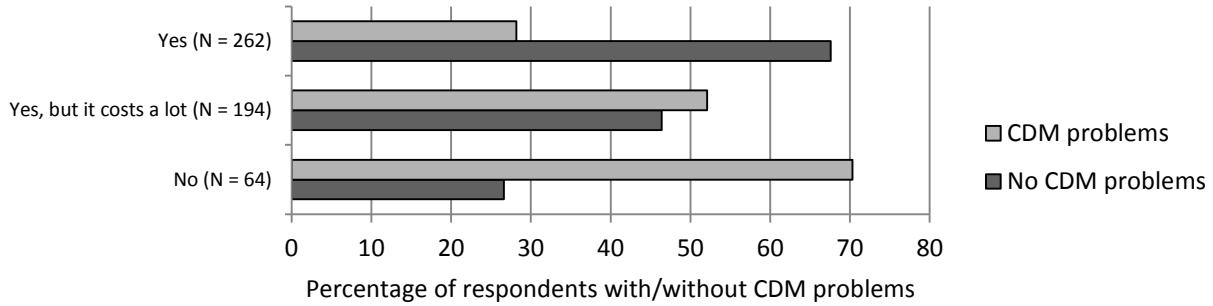

Figure 4. Responses to the item 'During the cold winter weather, can you normally keep comfortably warm in your living room' for respondents with and without CDM problems.

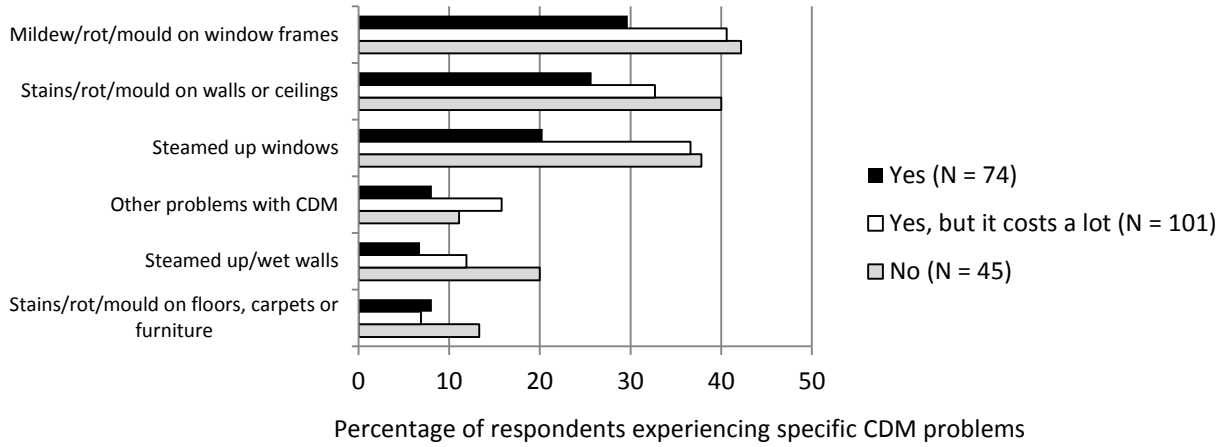

Figure 5. Responses to the item 'In your living room do you have any of these issues?', depending on whether respondents can keep their living room comfortably warm in winter.

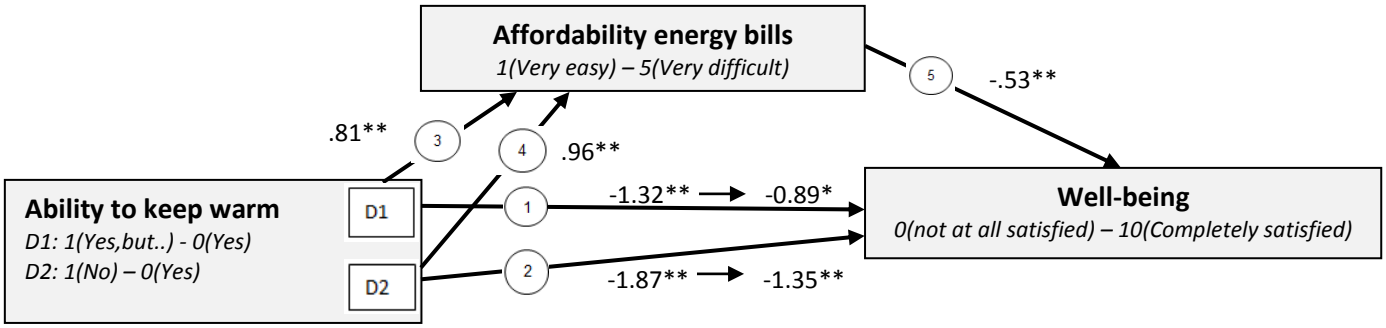

Figure 6. The mediation effect between the ability to keep the living room comfortably warm, affordability of energy bills, and well-being. Unstandardized regression coefficients are presented; asterisks indicate the significance of the coefficients. *p < .05. **p < .001. Sample size *N* = 469.

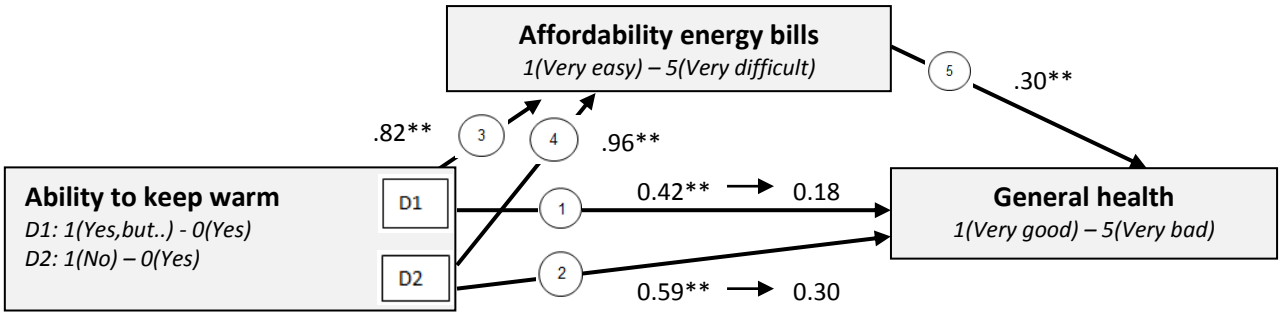

Figure 7. The mediation effect between the ability to keep the living room comfortably warm, affordability of energy bills, and general health. Unstandardized regression coefficients are presented; asterisks indicate the significance of the coefficients. *p < .05. **p < . 001. Sample size *N* = 461.

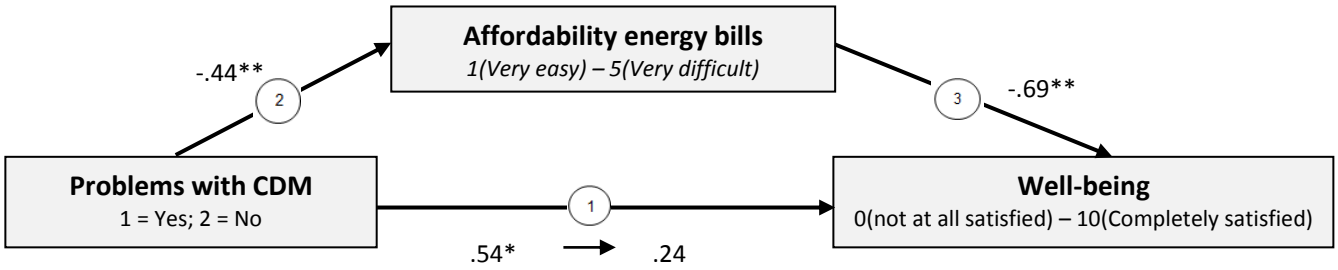

Figure 8. The mediation effect between problems with CDM, affordability of energy bills, and well-being. Unstandardized regression coefficients are presented; asterisks indicate the significance of the coefficients. *p < .05. **p < .001. Sample size *N* = 466.

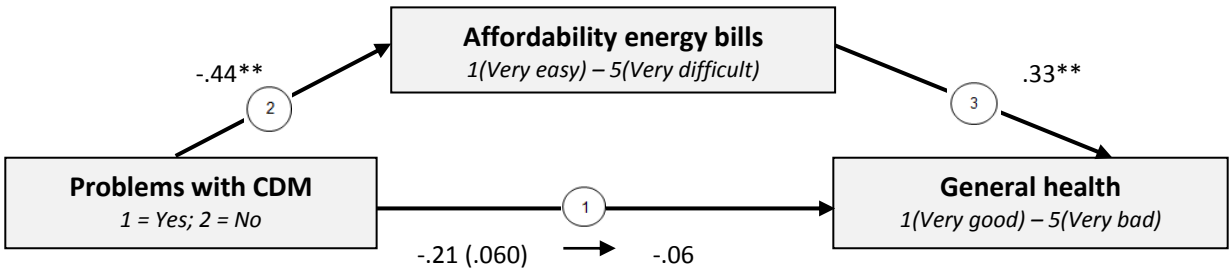

Figure 9. The mediation effect between problems with CDM, affordability of energy bills, and general health. Unstandardized regression coefficients are presented; asterisks indicate the significance of the coefficients. *p < .05. **p < .001. Sample size *N* = 460.

Appendix A
Mediation analyses for male and female respondents

First, looking at the relationship between keeping warm, energy affordability and well-being, a partial mediation effect was found for male and female respondents. Support for the mediating effect of energy affordability was somewhat stronger for females in this case – in particular when looking at Arrow 2 in the model (see Figure A1a and A1b). Compared to females, not being able to keep warm was more strongly related to reduced well-being for male respondents. This relationship remained strong even after controlling for affordability concerns.

Second, for the relationship between keeping warm, energy affordability and general health a mediation effect was found for D1 (keeping warm, but it costs a lot) in males and females, but the mediation effect for D2 (not being able to keep warm) was only supported for males (see Figure A2a and A2b).

Third, when examining the relationship between problems with CDM, energy affordability and well-being and general health, a mediation effect was supported for male respondents (see Figure A3b and A4b), but not for female respondents. A significant relationship between problems with CDM and well-being (Figure A3a), and general health (Figure A4a), could not be found for female respondents.

1. Keeping warm, affordability and well-being

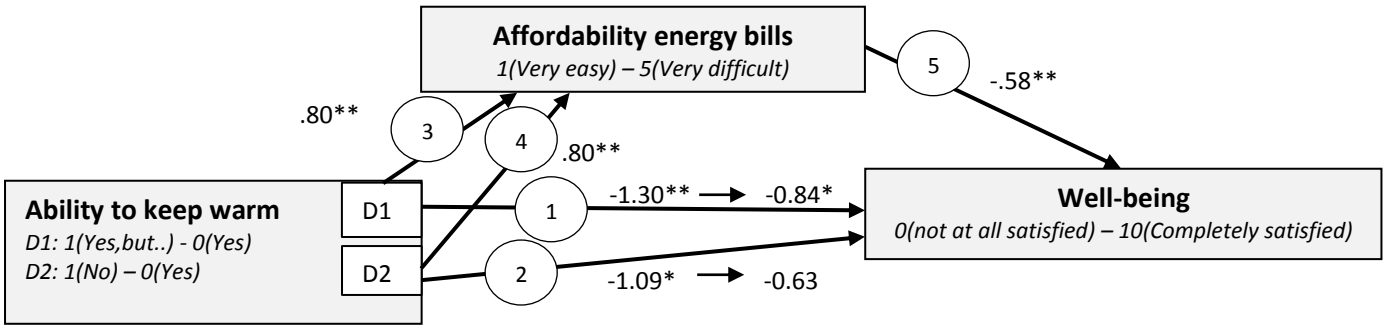

Figure A1a. Female respondents, sample size *N* = 262. The mediation effect between the ability to keep the living room comfortably warm, affordability of energy bills, and well-being. Unstandardized regression coefficients are presented; asterisks indicate the significance of the coefficients. *p < .05. **p < .001.

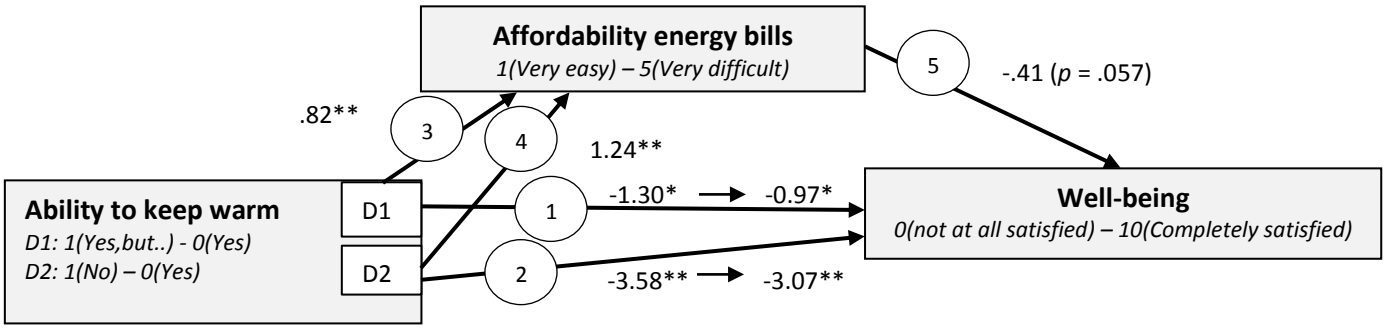

Figure A1b. Male respondents, sample size *N* = 187. The mediation effect between the ability to keep the living room comfortably warm, affordability of energy bills, and well-being. Unstandardized regression coefficients are presented; asterisks indicate the significance of the coefficients. *p < .05. **p < .001.

2. Keeping warm, affordability and health

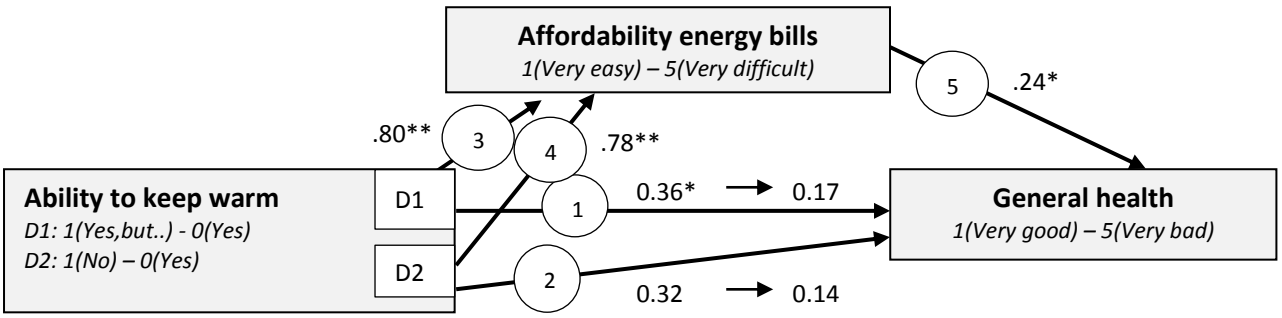

Figure A2a. Female respondents, sample size *N* = 257. The mediation effect between the ability to keep the living room comfortably warm, affordability of energy bills, and general health. Unstandardized regression coefficients are presented; asterisks indicate the significance of the coefficients. *p < .05. **p < . 001.

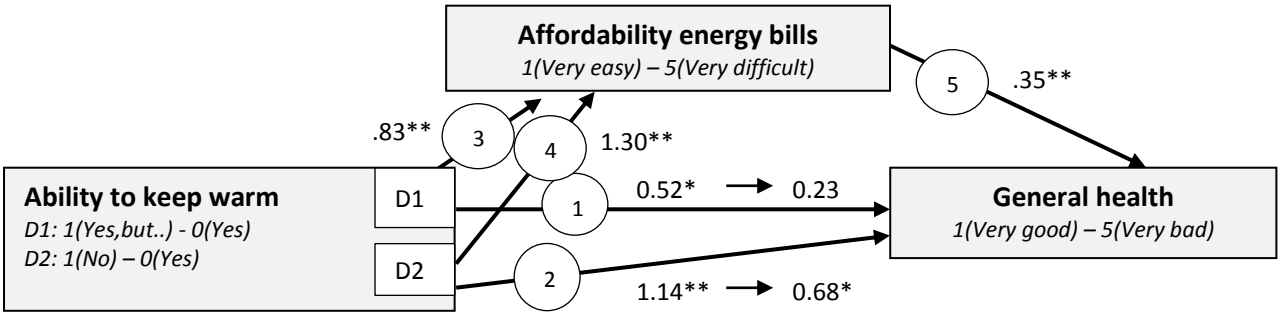

Figure A2b. Male respondents, sample size *N* = 184. The mediation effect between the ability to keep the living room comfortably warm, affordability of energy bills, and general health. Unstandardized regression coefficients are presented; asterisks indicate the significance of the coefficients. *p < .05. **p < . 001.

3. CDM problems, affordability and well-being

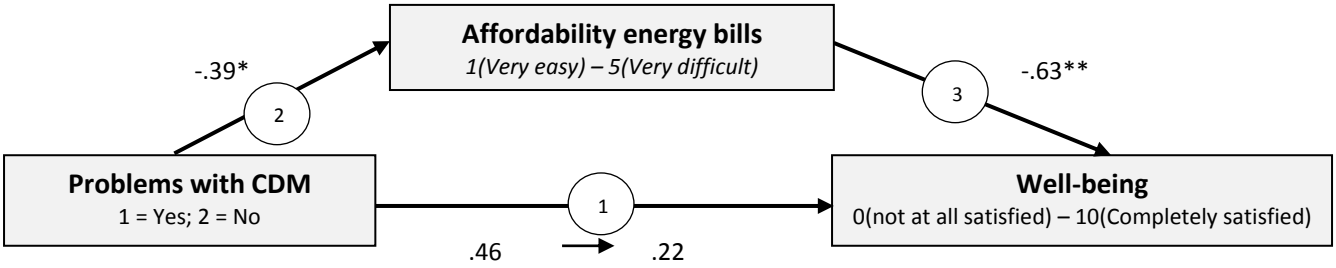

Figure A3a. Female respondents, sample size *N* = 260. The mediation effect between problems with CDM, affordability of energy bills, and well-being. Unstandardized regression coefficients are presented; asterisks indicate the significance of the coefficients. *p < .05. **p < .001.

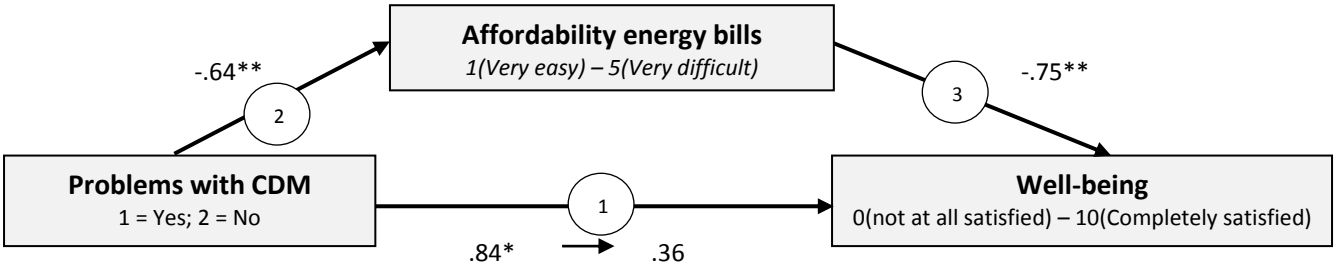

Figure A3b. Male respondents, sample size *N* = 187. The mediation effect between problems with CDM, affordability of energy bills, and well-being. Unstandardized regression coefficients are presented; asterisks indicate the significance of the coefficients. *p < .05. **p < .001.

4. CDM problems, affordability and health

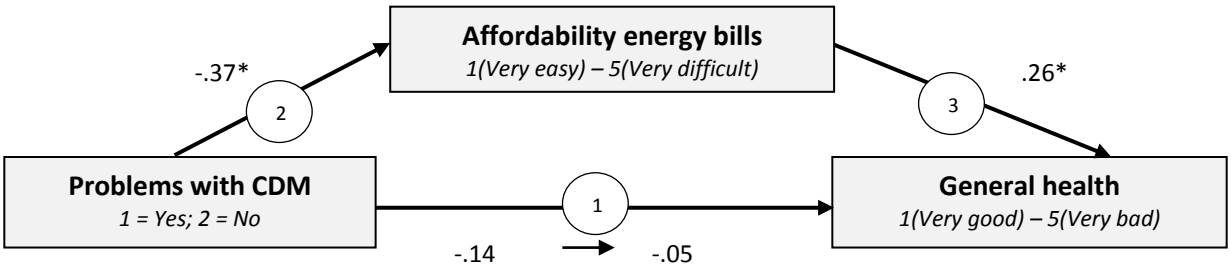

Figure A4a. Female respondents, sample size *N* = 257. The mediation effect between problems with CDM, affordability of energy bills, and general health. Unstandardized regression coefficients are presented; asterisks indicate the significance of the coefficients. *p < .05. **p < .001.

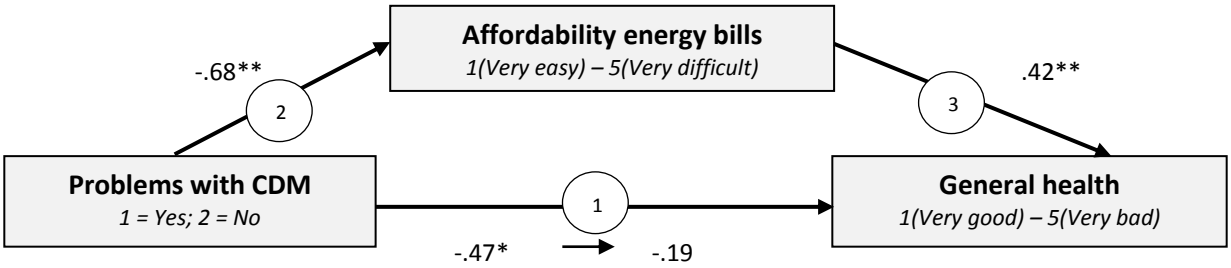

Figure A4b. Male respondents, sample size *N* = 184. The mediation effect between problems with CDM, affordability of energy bills, and general health. Unstandardized regression coefficients are presented; asterisks indicate the significance of the coefficients. *p < .05. **p < .001.