instytut badań strukturalnych

IBS WORKING PAPER 10/2020
DECEMBER 2020

ENERGY POVERTY, HOUSING CONDITIONS, AND SELF-ASSESSED HEALTH: EVIDENCE FROM POLAND

Jakub Sokołowski
Jan Frankowski
Piotr Lewandowski

IBS Working Paper 10/2020

December 2020

ENERGY POVERTY, HOUSING CONDITIONS, AND SELF-ASSESSED HEALTH: EVIDENCE FROM POLAND•

Jakub Sokołowski♦

Jan Frankowski♣

Piotr Lewandowski♥

Abstract

Inefficient heating and insufficient access to energy services can turn a shelter into a health hazard. We study how energy poverty associated with having substandard housing and ineffective heating is related to the risk of developing poor health in an urban context. We conducted a survey of 1,735 individuals living in two middle-sized cities in a coal-dependent region of Poland. We use objective and subjective indicators to measure energy poverty, and self-assessed health status to identify individuals with respiratory, cardiovascular, and musculoskeletal diseases. We find that compared to people living in suitable housing conditions, people who live in substandard housing are more likely to exhibit poor musculoskeletal and cardiovascular outcomes, on average by 10.6 and 6 pp, respectively. Our results also indicate that the energy-poor who use a coal or a wood stove in an apartment have a higher likelihood of developing a respiratory disease (by 27.9 pp on average) than people in energy poverty connected to district heating. In addition, we find that 16% of the explained variance in the probability of developing a respiratory disease is attributable to energy poverty.

Keywords: energy poverty, heating, housing, health, pollution

JEL: I14, I32, D10, Q53

• This paper was financially supported by the European Climate Foundation. We thank Karol Madoń for his insightful comments. The usual disclaimers apply. All errors are ours.

♦ Institute for Structural Research, University of Warsaw. Corresponding author. E-mail: jakub.sokolowski@ibs.org.pl

♣ Institute for Structural Research, Institute of Philosophy and Sociology of the Polish Academy of Sciences. E-mail: jan.frankowski@ibs.org.pl

♥ Institute for Structural Research, Institute of Labor Economics, Bonn. piotr.lewandowski@ibs.org.pl

1. Introduction

The quality of the housing people occupy affects their health. Living in low-quality housing can expose an individual to a number of health risks, from an injury on a loose step, to poor respiratory outcomes due to mould and indoor pollution, to stress due to the fear of eviction. In particular, a housing situation can become a health threat if it does not provide the tenants with proper heating or cooling or adequate access to electricity and energy appliances. These characteristics of substandard housing are in line with a widely used definition of energy poverty, which is generally understood as the inability of the inhabitants to adequately warm, cool and use energy appliances in their house (Boardman, 2010). Moreover, houses have become workplaces, classrooms, movie theatres, and gyms during lockdowns due to the COVID-19 pandemic. Therefore, whether people have access to affordable energy and heating at home has become a pressing issue for public policy.

In this paper, we study the relationship between energy poverty, housing conditions, and poor health outcomes in the context of industrial cities in Poland. We strive to make three key contributions.

First, we account for several dimensions of energy poverty, and examine the question of whether particular dimensions are associated with the risk of developing a specific disease. The majority of studies on energy deprivation and health have been focused on indoor pollution and respiratory diseases among households in the Global South (Agrawal, 2012; Oxlade and Murray, 2012; Hulin et al., 2012). Most of the research on this topic conducted in the Global North has been focused on the housing environment and health improvements resulting from retrofit interventions, particularly in the Anglo-Saxon countries (Preval et al., 2010; Heyman et al., 2011; Gilbertson et al., 2012; Maidment et al, 2014; Grey et al., 2017). We contribute to the literature by distinguishing between multiple aspects of energy poverty, in particular between monetary deprivation and poor housing conditions, such as leaking roofs or damp walls. We also distinguish between various diseases – respiratory, cardiovascular, and musculoskeletal – and quantify the associations between particular forms of deprivation and the risk of developing each of these diseases.

Second, we examine whether the risk factors of specific diseases differ substantially between people who are in energy poverty and those who are not. Living in an "unhealthy home" can be detrimental to people's mental and physical health, particularly if they have pre-existing diseases (Poortinga et al., 2017). Evidence has been found of a relationship between living in substandard housing, cold exposure, and having poor respiratory outcomes (Ormandy and Ezratty, 2012; Thomson and Thomas, 2015); and between having a low income and having increased exposure to environmental risk (Braubach and Fairburn, 2011). However, the relationship between experiencing energy poverty and developing diseases within different social groups is still under-researched. The initial studies on this topic have underlined the need to investigate and address the impact of experiencing energy poverty on the health of vulnerable groups (Liddell and Morris, 2010). Researchers have pointed out the severity of energy poverty among ethnic minorities in the United States (Jessel et al., 2019), young people in New Zealand (O'Sullivan et al., 2017), and solitary elderly residents in Ireland (Goodman et al., 2011). Our study adds to this knowledge by providing evidence on how the energy-poor and non-energy-poor subpopulations differ in terms of their exposure to health risks associated with living in various housing and heating conditions.

Third, we situate our study in the context of industrial cities in Poland that are in the process of transforming their energy systems and urban environment (Sýkora and Bouzarovski, 2012). There is a significant gap in

knowledge about the relationship between having poor health outcomes, living in substandard housing conditions, and being dependent on inefficient heating sources in Central and Eastern European countries. This issue is particularly relevant for Poland, as more than 40% of Polish households live in multifamily buildings built between the 1960s and the 1980s (Statistics Poland, 2018a), and more than 45% of households are using coal or wood to heat their houses (Statistics Poland, 2019).

For the purposes of our study, we collected data from a randomly selected sample of 700 households in two cities in the industrial and mining region of Upper Silesia in Poland. Upper Silesia is the largest hard coal mining region in Europe, and 13 out of the 50 European cities with the highest air pollution levels are located in it (WHO, 2018b). We selected two cities with different characteristics: Ruda Śląska, a mining city that is starting to break from its previous dependence on coal; and Tychy, a city with a recent history of dynamic socio-economic transformation. Using this approach, we are able to quantify the relationship between energy poverty and health outcomes in two different urban settings.

We find that people living in substandard housing face a higher risk of developing musculoskeletal and cardiovascular diseases (on average, by 10.6 and 6 pp, respectively) than people living in suitable housing conditions. This relationship has rarely been assessed in previous studies investigating the relationship between health and housing conditions, which mainly focused on general subjective health assessments or specific diseases (e.g., asthma). We show that among the energy-poor, the type and the location of the main heating source is related to the higher risk of developing a respiratory disease. Specifically, we find that among people in energy poverty, those living in an apartment with a coal or a wood stove have a risk of experiencing poor respiratory outcomes that is higher (by 27.6 pp on average) than that of those living in an apartment connected to district heating. We demonstrate that 16% of the explained variance in the probability of having poor respiratory outcomes is attributable to energy poverty. These results prove that indoor pollution is an issue not only in the Global South, but in developed countries as well. We also find evidence of differences between cities at different stages of modernisation. For example, we find that the incidence of energy poverty is higher in Ruda Śląska, a city with an older urban structure and more widespread use of solid fuels as a heating source. We also find that energy-poor households are clustered in traditional mining estates, beyond the range of district heating. To the best of our knowledge, this study is the first to provide such a detailed analysis of the relationship between energy poverty and health using a purposefully and locally collected dataset.

We situate our paper in the strand of research that emphasises the regional and the urban dimensions of energy poverty (Bouzarovski and Thomson, 2018; Frankowski and Tirado Herrero, 2021). The most recent quantitative studies based on large-scale household surveys (such as EU Statistics on Income and Living Conditions) found a relationship between energy poverty and poor health outcomes on the pan-European level (Thomson et al., 2017a; Oliveras et al., 2020), as well as in selected EU countries (Lacroix and Chaton, 2015; Kahouli, 2020; Llorca et al., 2020), Turkey (Kose, 2019) and China (Zhang et al., 2019). Another recent study cited energy poverty as the reason for excess winter mortality, especially in the most vulnerable Mediterranean and CEE countries (Recalde et al., 2019). Moreover, it has been shown that heat stress during hotter summers is a significant risk factor associated with energy poverty, as being deprived of indoor cooling is especially harmful for older people (Thomson et al., 2019). Although they were based on large-scale data sources, these studies provided only a general overview of health and living conditions. Our study, by contrast, is more detailed, and allows us to examine how the risk of developing particular diseases is related to exposure to particular housing standards and heating sources.

Our paper is structured as follows. In the second section, we introduce the data, the energy poverty indicators and subjective health measures, and the econometric methodology we use. In the third section, we present our results. In the fourth section, we discuss our conclusions, and offer policy recommendations.

2. Methodology and data

2.1. Data collection in Ruda Śląska and Tychy

To investigate the relationship between energy poverty and health, we collected survey data in two middle-sized cities located in the Upper Silesia: Ruda Śląska and Tychy. We used a computer-assisted personal interview (CAPI) with randomly selected households (Map 1). The questionnaire included 20 questions concerning health conditions and services, and household energy practices and expenditures. We instructed the pollsters to ask only people who were well-acquainted with issues related to household energy consumption and budgets to complete the questionnaire. The data were collected in February 2020. We obtained 700 complete answers (350 households in each city for a total of 1,735 individuals, 895 in Ruda Śląska and 840 in Tychy).[1] The average response rate was 30.9%, which we consider acceptable due to the nature of the particular questions, which touched on issues of physical and mental health (OECD, 2013). We further validated the results of the survey through geolocalisation (full sample), via telephone, and in person (13% of addresses). In each city, the sample covered 0.65% of the population. We weighted the sample with population weights representative of the age and gender composition in Ruda Śląska and Tychy, and of the household structure in Śląskie Voivodeship.[2]

We selected Ruda Śląska and Tychy for our study because these cities are similar in terms of their size and population, but differ in terms of their economic profile and spatial planning. The cities have a similar number of inhabitants (138,000 – Ruda Śląska, 127,831 – Tychy in 2018; Statistics Poland, 2018b), and both border Katowice, the capital of Upper Silesia.[3] They are also similar in terms of their area, demographic structure, and registered unemployment rate. However, in 2020, Ruda Śląska is an industrial town with a large coal mining sector and three active coal mines. Tychy, by contrast, has no coal mining, but it does have a large manufacturing sector and a growing service cluster.

Tychy and Ruda Śląska also differ in terms of their urban structures and spatial planning. Among the most characteristic elements of Ruda Śląska's urban structure are the 20 multi-family estates located near the coal mines (Szweda, 2018), which can be seen as a material metaphor for how the mining industry is related to the everyday lives of the city's inhabitants. Ruda Śląska also has large-scale apartment blocks built in the 1960s and 1970s; i.e., during the period when the mining sector was being most intensively developed. Tychy was also built mostly in the 1960s and 1970s, and was deemed a "socialist role-model city" in which a clear division

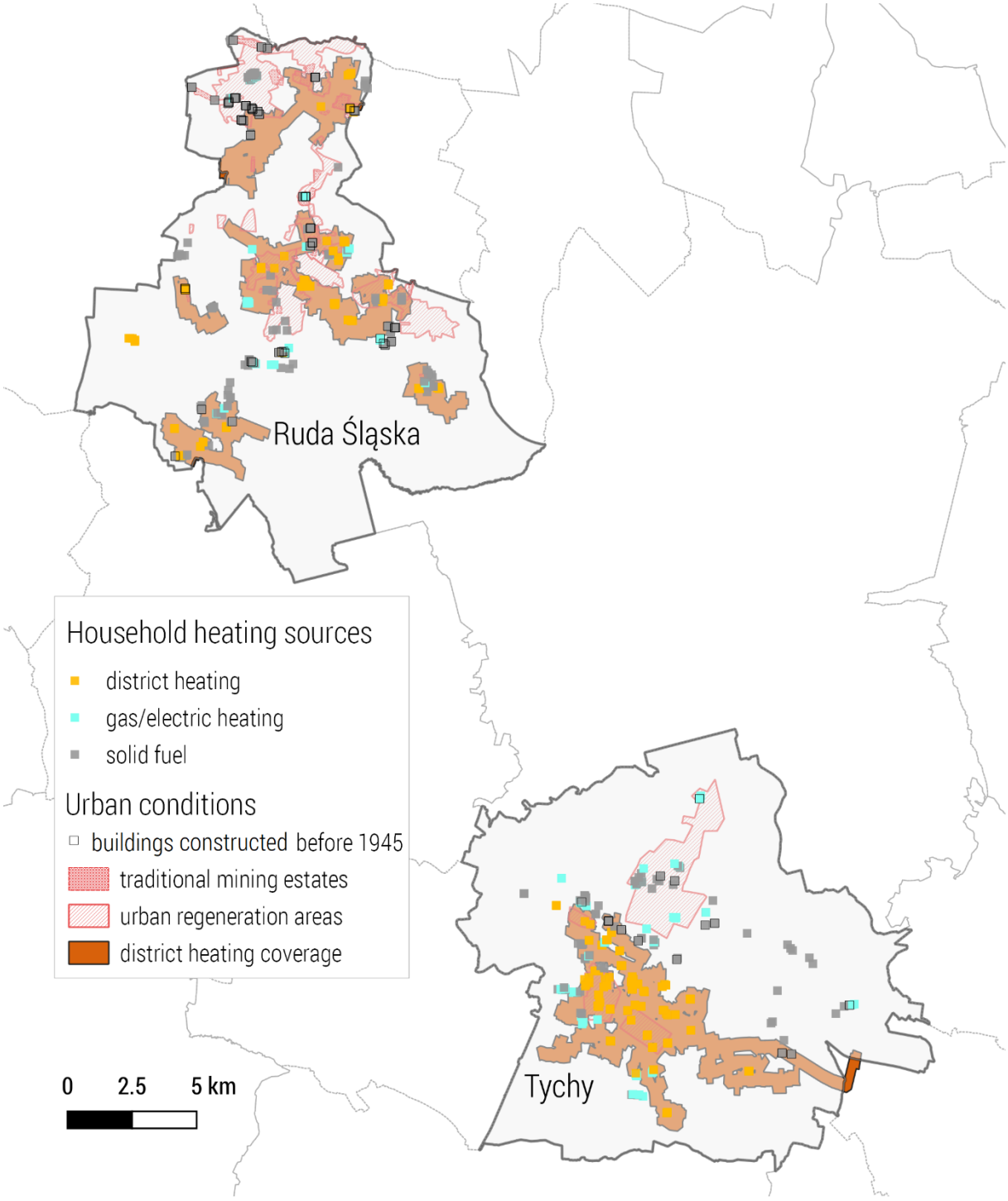
[1] Descriptive statistics of our sample are shown in Table A1 in the Appendix.

[2] The weighting procedure is described in Table A2 in the Appendix.

[3] Upper Silesia is the most urbanised Polish region. In 2019, it had a population of 4.5 million (12% of the total Polish population). It has long been a crucial production and export region in Poland, even though its share of the national GDP has been decreasing since 2010. The region stands out for its high concentration of heavy industries (mining, metallurgy, and energy production).

between the residential and the industrial areas persists until the present day (Bierwiaczonek, 2016). In both cities, there are also individual, single-family houses.

Map 1. Spatial distribution of households in Ruda Śląska and Tychy according to the main heating source and the urban characteristics



Source: own elaboration based on the survey data collected in Ruda Śląska and Tychy (n = 700)

2.2. Definitions and indicators

Energy poverty

We define energy poverty as an inability to adequately warm, cool, and use energy appliances within a household (Boardman, 2010). We use five energy poverty indicators (Thomson et al., 2017):

1. Low Income, High Cost

A household is classified as energy-poor if it fulfils two criteria simultaneously: it has high required energy expenditures and a low income. The high required energy expenditure criterion is met if the household's required equivalent energy expenses are higher than the median of the equivalent energy expenditures in the sample. The low-income criterion is based on two conditions that must be met simultaneously: (i) the equivalent household income is in the lowest 30% of incomes in the sample, and (ii) the equivalent household income after housing costs is lower than the individual income threshold.

2. High actual costs

A household is classified as energy-poor if the share of its income it spends on energy is at least double the median of this share in the sample.

3. Housing faults

Indicator based on the following survey question: "In your view, does your apartment have a leaking roof; damp walls, floors, or foundations; or rotting window frames or floors?" The households answering "yes" are classified as energy-poor.

4. Inadequate thermal comfort

Indicator based on the following survey question: "In your view, is your apartment warm enough in the winter?" The households answering "no" are classified as energy-poor.

5. Difficulties paying bills

Indicator based on the following survey question: "How often, exclusively due to financial reasons, did you give up on paying energy bills?" The households answering "often", "very often", and "always" are classified as energy-poor.

Health outcomes[4]

We consider three[5] subjective health outcomes indicators in our study (OECD, 2013a; DECC, 2016):

1. Respiratory diseases (respiratory failure, flu, pharyngitis, pneumonia, asthma, chronic obstructive pulmonary disease, chronic cold)
2. Cardiovascular diseases (high blood pressure, coronary disease, diabetes, atherosclerosis, varices, stroke)
3. Musculoskeletal diseases (muscle and joint pain or inflammation, arthritism, rheumatism, osteoporosis)

We consider the survey respondents to have a health issue if they meet at least one of the following conditions:

1. Self-diagnosed disease

Indicator based on the following survey item: "Name each member of your household who has experienced the following disease in the last 12 months". Each person for whom the respondent answered "yes, but the disease was not confirmed by a doctor", is classified as ill.

2. Disease confirmed by a doctor / nurse

Indicator based on the following survey item: "Name each member of your household who has experienced the following disease in the last 12 months". Each person for whom the respondent answered "yes, and the disease was confirmed by a doctor", is classified as ill.

3. At least one visit to the doctor's / nurse's office during the last 12 months due to a particular disease.

Indicator based on the following survey question: "How many times, and due to what condition, has a member of your household visited a doctor / nurse?" Each person for whom the respondent answered "yes" and named a specific disease is classified as ill.

4. At least one 12-hour stay in the hospital during the last 12 months due to a particular disease.

Indicator based on the following survey question: "How many times, and due to what conditions, has a member of your household stayed in the hospital for at least 12 hours?" Each person for whom the respondent answered "yes" and named a specific disease is classified as ill.

---

[4] We also included questions on psychiatric / other disorders in the questionnaire. The response rates for these questions were low, and would not allow for detailed modelling. We matched the diseases from the "other" category to the three main disorders in all of the cases the data allowed. We decided against modelling the remaining responses, as they differed substantially; e.g., allergies and cancer would be included in one category of disorders. Detailed data for the psychiatric / other disorders are available upon request.

[5] Each indicator provides supplementary information: the correlation between particular indicators is relatively low. The highest observed correlation between the components of an indicator is 0.81 between a cardiovascular disease confirmed by a physician and a doctor's appointment in the last 12 months due to this condition. The lowest is -0.12 between a self-diagnosed respiratory disease and respiratory issues confirmed by a doctor. The correlations between particular components are presented in the Appendix, Table A3.

2.3. Logistic regression model

In order to analyse the factors that are related to the coincidence of energy poverty and self-reported health issues at the individual level, we estimate logistic regressions. In particular models, we assign a value of one if an individual reports a specific health condition as a dependent variable. Formally:

$$\Pr(health\ outcome_i = 1) = F(\beta_0 + \beta_1 X_i + \beta_2 B_i + \beta_3 \gamma_i + c_i + \epsilon_i) \quad (1)$$

where $F(H) = \frac{e^H}{1+e^H}$, i stands for the individual, X_i is a vector of energy poverty dimensions, B_i, is a vector of the building's characteristics (e.g., heating source, year of construction), γ_i stands for a vector of socio-economic controls, and c_i is the city fixed effect. We control for socio-economic characteristics (equivalised income, social transfers) to account for the observed differences in the living conditions. We use individual controls (age, gender) to account for differences among the household members.

Our sample includes individuals who reported their household income.[6] We have equivalised the incomes by making them comparable among households with different compositions. We use the income equivalisation scale according to the methodology of the OECD (2013b). We estimate our models on two samples. First, we estimate the model on a pooled sample of 1,215 observations. Second, we re-estimate the model on a subsample of individuals identified as energy-poor (465 observations) for whom the risk of having particular health outcomes may be different than that of individuals who are not experiencing energy poverty. We classify a person as energy-poor if the individual is affected by at least one of the five energy poverty dimensions.

Finally, in order to assess the relative effects of the energy poverty indicators, the building characteristics, and the individual and household traits on the probability of having particular health outcomes, we use the Shapley decomposition method proposed by Shorrocks (2013). In the decomposition, we distinguish between five groups of variables (Table 1).

Table 1. Variable groups for the Shapley decomposition and data description for selected variables

#	Groups for Shapley decomposition	Variable	Description
1	socio-economic	age in 2020, four dummies	0-20
			21-40
			41-60
			60 and more
		female	dummy variable
		logarithm of placement on subjective health scale	self-assessed health scale, where 0 is the lowest and 100 the highest
		logarithm of equivalised income	sum of the household's income from all sources (wages, social transfers, etc.)
		labour market status, nine dummies	manager / professional
			technician / clerical support
			services
			crafts
			machines / elementary
			unemployed

[6] We have excluded 520 individuals who did not report their household income in the survey.

			school / university student
			retired or pensioner
			beneficiary of a social transfer
2	city	Tychy	city dummy variable
3	building characteristics	multifamily building	dummy variable
		year of construction, four groups	before 1945
			1946-1960
			1961-1980
			after 1980
		ownership, three dummies	outright
			municipal
			housing association
		logarithm of floor area	floor area in square meters
		construction material, three dummies	wood
			concrete / panel building
			bricks
		main heating source, four dummies	district heating
			coal / wood stove in the apartment
			coal / wood stove in the boiler room
			oil / gas / other
		uninsulated	dummy variable
		leaking doors / windows	
		unventilated house	
4	social transfers	beneficiary of housing / energy / heating / coal allowance	dummy variable
		beneficiary of social / unemployed allowance / charity	
		beneficiary of coal allowance	
5	energy poverty indicators	low income high cost	dummy variable
		high actual energy costs	
		housing faults	
		difficulties paying bills	
		inadequate thermal comfort	

Source: own elaboration

3. Results

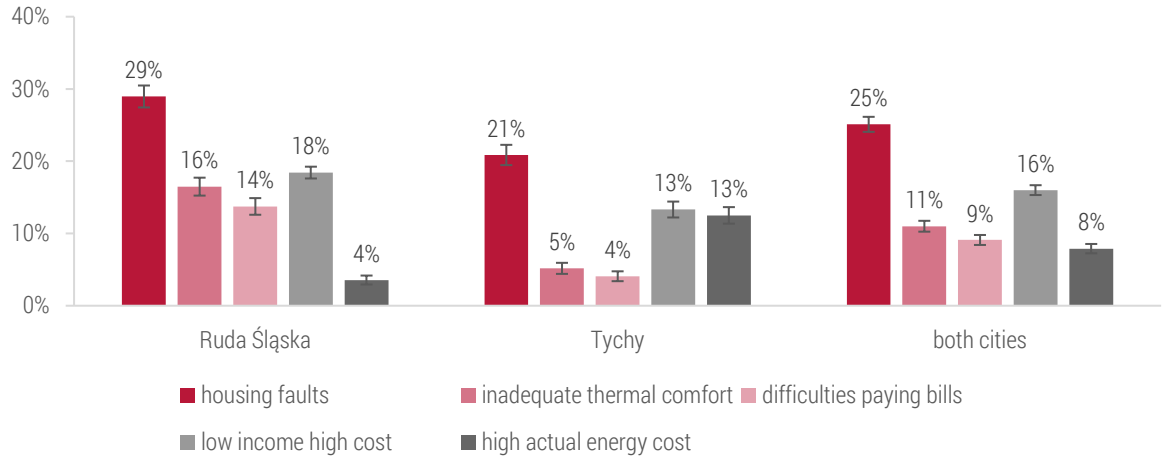
3.1. Descriptive results

3.1.1. Energy poverty

As the main aim of our study is to examine whether living in substandard housing conditions is associated with the risk of developing particular diseases, in our analysis of the incidence of energy poverty, we focus mainly on two subjective indicators (housing faults and inadequate thermal comfort). We find that almost 30% of the respondents in Ruda Śląska and more than 20% of the respondents in Tychy reported living in an "unhealthy house"; i.e., in a mouldy house with leaking windows or a leaking roof (Figure 1). More than 10% of the

respondents indicated that they cannot heat their home adequately. A higher share of people in Ruda Śląska are identified as energy-poor based on four out of five energy poverty indicators. This may be because almost half (47%) of the respondents in Ruda Śląska indicated that they live in a building built before 1960 (whereas only one in four of the respondents in Tychy said they live in an older building).

Figure 1. Share of the population in Ruda Śląska and Tychy identified as energy-poor (%)

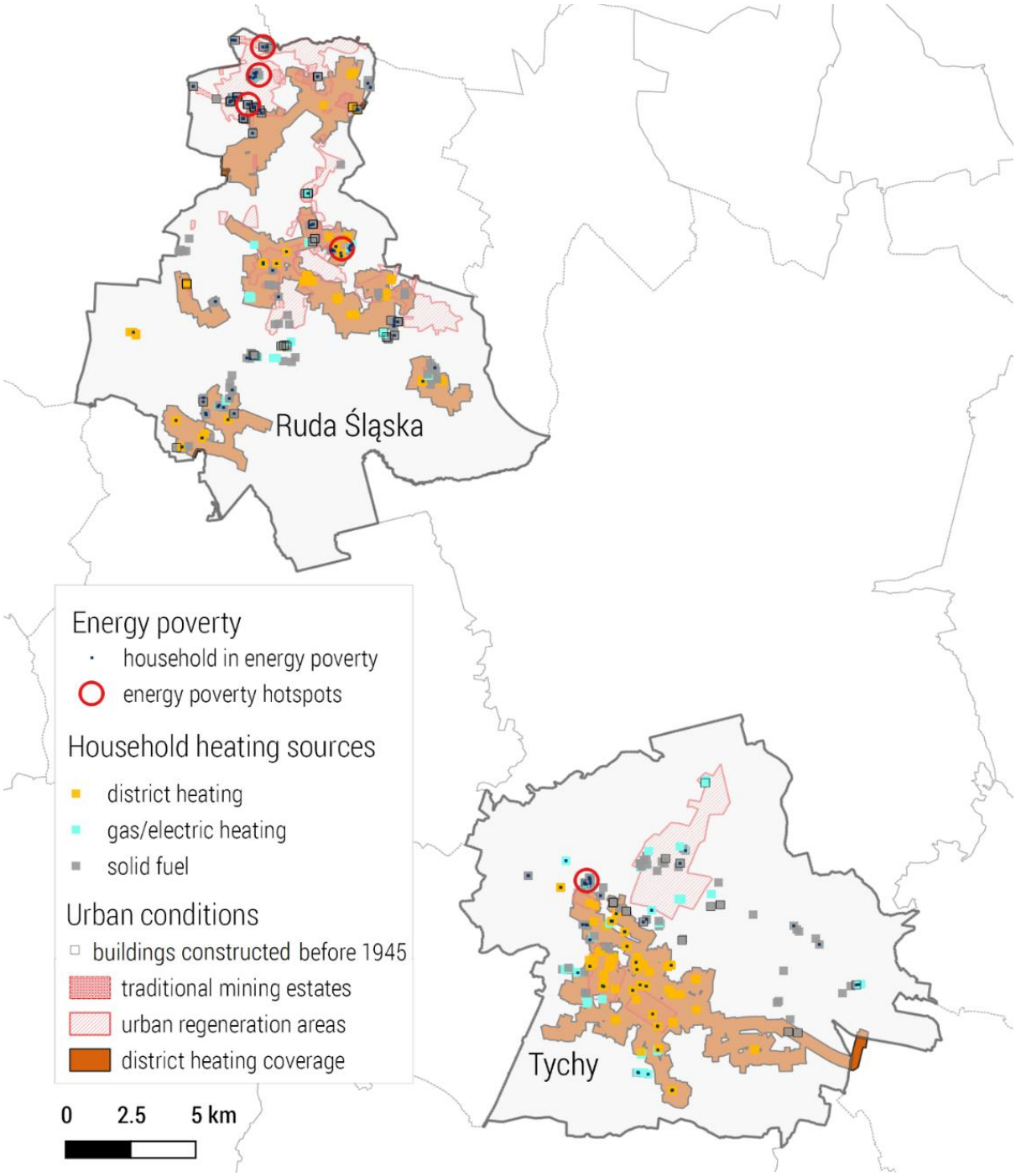


Source: own elaboration based on the survey data collected in Ruda Śląska and Tychy (n = 1,735)

Our finding that a higher share of the respondents are living in energy poverty in Ruda Śląska than in Tychy is related to the differences in the socio-spatial characteristics of these cities. Compared to Tychy, Ruda Śląska has an older urban structure, a higher share of households using solid fuels as a heating source (57%, compared to 25% in Tychy), and a lower share of households living in multifamily estates connected to district heating (56% in Tychy and 31% in Ruda Śląska). We find an interesting pattern of the spatial distribution of energy poverty depending on housing faults (Map 2). Most of the energy poverty hot-spots are located beyond the range of the neighbourhoods with district heating, and in particular in the northern districts of Ruda Śląska. These neighbourhoods are located in areas undergoing urban regeneration[7], and in traditional mining estates where the inhabitants mostly rely on individual solid fuel heating.

[7] We define urban regeneration as the implementation of an urban policy response in an area in a crisis (in terms of the social, economic, functional, technical, and environmental domains).

Map 2. Spatial patterns of energy poverty in Ruda Śląskie and Tychy

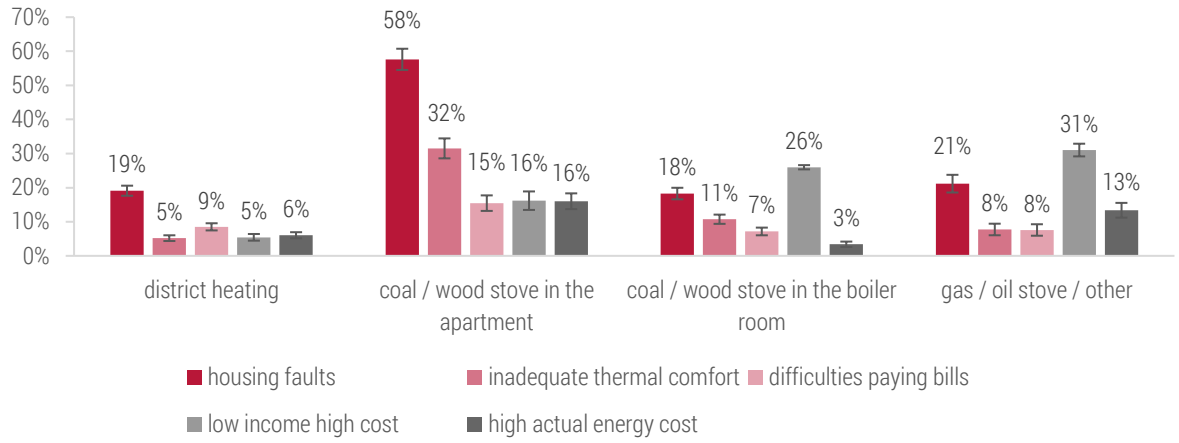


Source: own elaboration based on the survey data collected in Ruda Śląska and Tychy (n = 1,735)

We also find important differences between households that use particular heating sources. According to most indicators, the share of individuals identified as suffering from energy poverty is significantly lower among those respondents who said they are connected to district heating. The majority (almost 60%) of the respondents who reported living in an apartment with a coal or a wood stove also said they have a faulty house. One in three of the respondents who reported using a solid fuel stove indicated that they find their house too cold, and 15% reported having problems paying their energy bills on time. At least 25% of the respondents who said they heat

their homes with a solid fuel stove also indicated that they have a low income and high heating expenses (Figure 2).

Figure 2. Share of the population in Ruda Śląska and Tychy identified as energy-poor by their main heating source and its location (%)

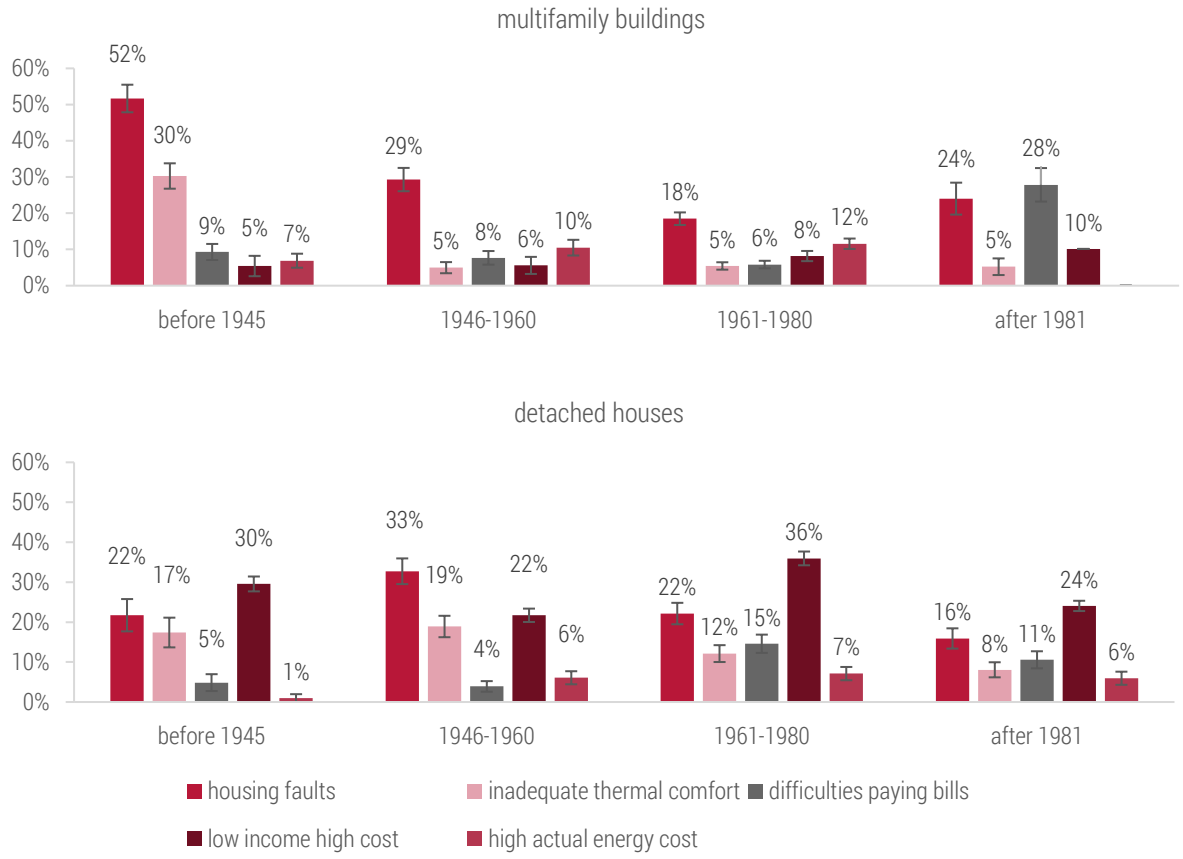


Source: own elaboration based on the survey data collected in Ruda Śląska and Tychy (n = 1,735)

Finally, our results confirm the findings of earlier research on energy poverty in Poland, which showed that housing conditions play an important role in energy poverty. First, it has been shown that the year a building was constructed and the type of building are major energy poverty risk factors (Bouzarovski and Tirado Herrero, 2017). In Poland, the oldest multifamily buildings are usually less energy efficient, and tend to be occupied by people with lower incomes (retirees or social transfer beneficiaries, Sokołowski et al., 2020). This is also the case in Ruda Śląska and Tychy, where more than half of the people living in a multifamily building constructed before 1945 reported having issues with mould or a leaking roof (Figure 3). Second, we find that almost 30% of the respondents living in one of the newest buildings (built after 1981) said that they have had trouble paying an energy bill. A similar result was reported in another regional study of energy poverty in Poland: Sokołowski and Frankowski (2020) found that in the Łódzkie voivodship, the inhabitants of the newest buildings reported having more difficulties paying their energy bills (controlling for their incomes). Finally, having a low income and high energy expenses[8] is the most common energy poverty dimension found among people who are living in detached houses. This result is consistent with the conclusions drawn in Lewandowski et al. (2018), who showed that in Poland, detached houses are expensive and difficult to heat (mostly due to a combination of low energy efficiency, solid fuel use, and large floor areas, which require high energy expenditures).

[8] By required energy costs we mean the costs that the household needs to incur in order to satisfy its energy needs, given the housing situation and household composition (Sokołowski et al., 2020).

Figure 3. Share of the population in Ruda Śląska and Tychy identified as energy-poor by year of building construction (%)

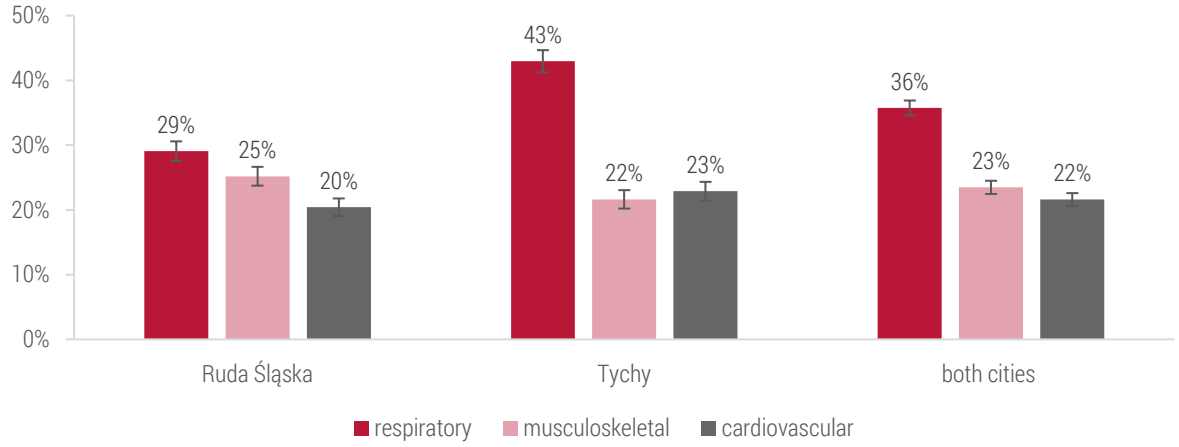


Source: own elaboration based on the survey data collected in Ruda Śląska and Tychy (n = 1,735)

3.1.2. Health outcomes

There are three major determinants of health that are related to socio-economic status: health care, environmental exposure, and health behaviour (Adler and Newman, 2002). We assess the socio-economic status of the respondents by their education and occupation. We also assess the respondents' levels of environmental exposure by analysing particular energy poverty dimensions and the main heating source used by the household. We find that having poor respiratory outcomes is the most common health condition in our sample, followed by developing cardiovascular and musculoskeletal disorders (Figure 4). This result may suggest that the prevalence of respiratory conditions is related not only to people's socio-economic status, but also to other factors, such as regional exposure to air pollution, as the two cities are located in a coal-intensive region with highly polluted air (WHO, 2018b).

Figure 4. Share of the population in Ruda Śląska and Tychy reporting poor health outcomes (%)

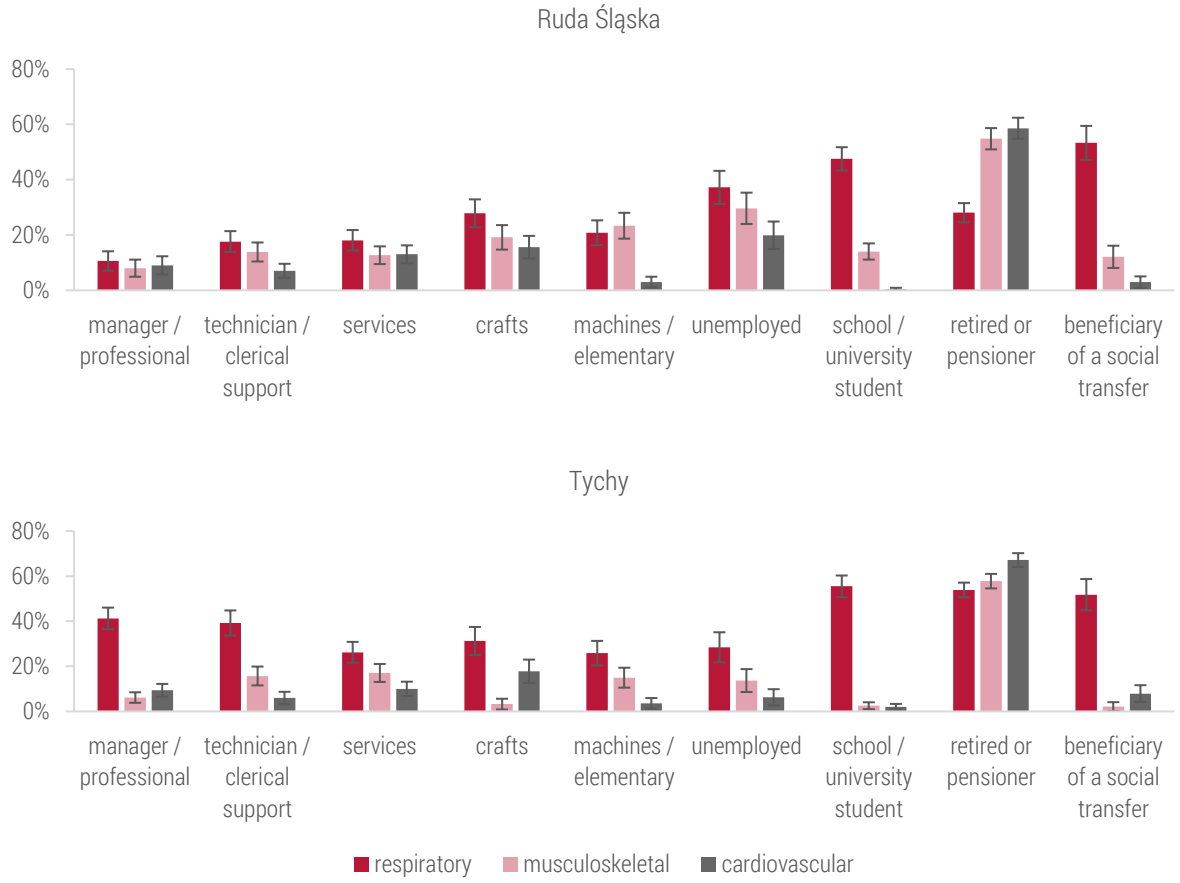


Source: own elaboration based on the survey data collected in Ruda Śląska and Tychy (n = 1,735)

We assess the link between socio-economic status and particular health disorders by analysing the differences between the economic structures of Ruda Śląska and Tychy that may contribute to local exposures. Our main focus is on miners, who are highly exposed to diseases. First, miners are often found to be at high risk of developing lung diseases (Laney and Weissman, 2014). In our sample, the share of craft and related trades workers (occupational category, which includes miners in our survey sample) who reported contracting a respiratory disease is relatively high, at 28% in Ruda Śląska and 31% in Tychy, (Figure 5). Interestingly, a high share of the managers and professionals surveyed in Tychy (around 40%) reported developing a respiratory disorder. This may suggest that in the case of poor respiratory outcomes, the occupational exposure to pollutants is less important than, for example, health behaviour or pre-existing immunity. However, the shares of managers, crafts, and professional workers who reported having respiratory issues is still considerably lower than the share of individuals living off social transfers or school and university students who reported having similar health problems (more than 50% in each city). This result suggests that the incidence of respiratory issues may be also related to general living standards.

Second, miners are also shown to be at higher risk of experiencing musculoskeletal disorders (Weston et al., 2016). Indeed, we find that the share of craft and related trades workers who reported having poor musculoskeletal outcomes is noticeably higher in the mining town of Ruda Śląska (19%) than in Tychy (3%). Additionally, we note that being older or younger is one of the most common correlates of poor health (Niccoli and Partridge, 2012), and our results are in line with this general pattern: more than 50% of the retirees and pensioners surveyed in each city reported having a musculoskeletal or a cardiovascular condition.

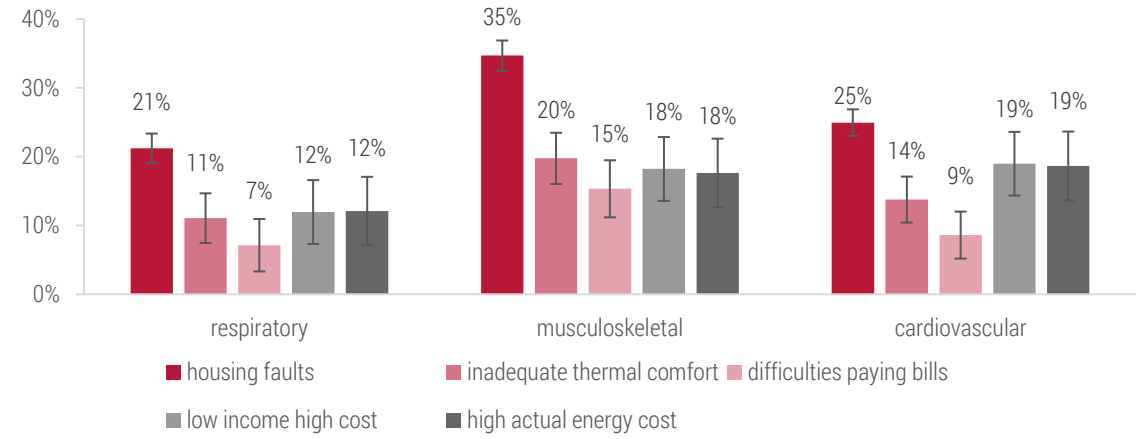
Figure 5. Share of the population reporting poor health outcomes by labour market status (%)



Source: own elaboration based on the survey data collected in Ruda Śląska and Tychy (n = 1,735)

For each type of disease, living in substandard housing conditions (e.g., mould; leaking windows, doors, or roof) is the most common energy poverty dimension observed among the individuals who reported developing a health issue (Figure 6). The shares of respondents who indicated that they suffer from any energy poverty dimension are found to be higher among those who reported developing a musculoskeletal or a cardiovascular disease than among those who reported developing a respiratory disorder. These patterns demonstrate that having a substandard housing situation and inadequate thermal comfort appear to be highly related to the risk of developing musculoskeletal disorders (Pienimäki, 2002), while social status seems to be more associated with the risk of having poor cardiovascular outcomes (Tang et al., 2016).

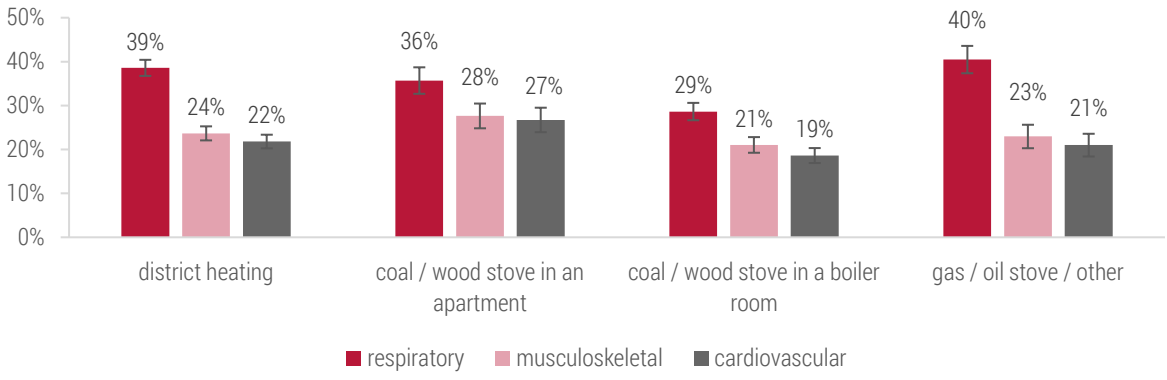
Figure 6. Share of people reporting a given medical condition by energy poverty dimensions (%)



Source: own elaboration based on the survey data collected in Ruda Śląska and Tychy (n = 1,735)

We find that the type and the location of the main heating source in the household is related to the levels of outdoor and indoor air pollution, and their relationship to poor health outcomes (Figure 7). Living in a household with an inefficient coal-fired stove inside the house may be associated with developing respiratory issues. We suspect that non-deprived households are more likely to be able to afford better quality fuel, and to heat the house with an efficient stove. Conversely, we assume that the energy-poor population (and, generally, lower income households) are more likely to use lower quality fuel and stoves. These households face pressure to adopt a variety of energy-saving strategies, but have limited choices because efficient fuel and stoves are expensive, and the retrofitting of the housing stock where they live may be delayed for years (Brunner et al., 2012).

Figure 7. Share of people reporting a given medical condition by main heating source (%)



Source: own elaboration based on the survey data collected in Ruda Śląska and Tychy (n = 1,735)

3.2. Econometric results: risk factors of poor health outcomes

The descriptive results suggest that there is a link between living in poor housing conditions and having poor health outcomes. Nevertheless, we have not yet answered the question regarding the relationship between living in housing with inefficient heating and other dimensions of energy poverty. In order to understand the

correlates of poor health, we estimate regression (1) on the total sample and on the sample of energy-poor individuals, controlling for building characteristics, heating sources, and socio-economic variables. This approach allows us to draw comparisons of the correlates of particular diseases (i.e., musculoskeletal, cardiovascular, and respiratory) for the individuals suffering from any dimension of energy poverty. While the methods we apply are in line with previous research (e.g., Llorca et al. 2020), we focus on detailed health outcomes, and on differences between individuals who are and are not in energy poverty.

Generally, we can distinguish two groups of health risk factors: those related to the housing situation, and those related to socio-economic variables. First, we discuss the correlates of poor health related to building characteristics and energy poverty dimensions. Second, we analyse the differences between people who own their apartment, and people who are renting an apartment in a municipal building. Next, we focus on the relationship between having inefficient heating sources and developing respiratory diseases. Finally, we discuss the socio-economic characteristics associated with being in poor health.

We find that there are two energy poverty dimensions that are correlated with poor health outcomes. First, we observe that individuals who live in a faulty house (with mould or a leaking roof) have a significantly higher risk of developing a musculoskeletal and a cardiovascular disease (on average by 10.6 and 6 pp, respectively) than people who live in suitable housing conditions (Table 2). Second, we find that individuals who spend a relatively large share of their income on heating are significantly more likely to develop a respiratory disease (by 18.5 pp on average) than people who are not in energy poverty.

Our results further indicate that people who live in municipal housing are at higher risk of poor health outcomes than those who own their apartment. Tenants of municipal buildings have a significantly higher risk of developing a musculoskeletal condition (by 11.1 pp on average) than apartment owners. This may be because the multifamily buildings owned by municipalities are often in poor condition, and lack basic amenities like an elevator.[9] Additionally, people's ownership status may affect their propensity to perform small-scale improvements and renovations (insulating windows and doors, getting rid of mould), and especially to make more expensive investments, such as deep retrofits (Muzioł-Węcławowicz and Nowak, 2018).

Importantly, we find that among people who are energy-poor, the type and the location of the main heating source are related to their risk of having poor health outcomes. Energy-poor individuals who report that they heat their home with a solid fuel stove located in their apartment are significantly more likely to develop a respiratory disease (by 27.9 pp on average) than energy-poor people who are connected to district heating.[10] The main heating source is not found to be a significant risk factor in the pooled sample. Therefore, we hypothesise that people who have substandard living conditions, high energy bills, and a low incomes are more likely to use inefficient heating sources and low-quality fuel (González-Eguino, 2015), and face higher levels of indoor air pollution.

[9] This have been the case for people who live in buildings owned by a municipality in the Łódzkie Voivodeship, one of the central regions of Poland (Sokołowski and Frankowski, 2020).

[10] Similarly, energy-poor people who heat their homes with gas or oil stoves have a higher risk of developing a respiratory disease (by 22.5 pp on average) than energy-poor individuals connected to district heating.

Similar socio-economic characteristics (e.g., lower subjective health, higher age)[11] are related to the risk of developing musculoskeletal and cardiovascular diseases. The main risk factors associated with developing respiratory diseases are found to be different from those related to having poor musculoskeletal and cardiovascular outcomes. The largest of these differences is that older people have a lower risk of developing respiratory diseases than younger people (by 20 pp on average). We hypothesise that children and younger people may be especially prone to developing particular respiratory disorders, such as flu and asthma (WHO, 2018a). Additionally, we find that the higher the equivalised income is, the higher the risk of developing a respiratory disease is (by 14.8 pp on average). We hypothesise that this result is attributable to better situated individuals having a greater awareness of health issues (Levin-Zamir et al., 2016; Kahneman and Deaton, 2010), rather than having a high income being a risk factor for developing a particular disease. Finally, the people living in Tychy are found to be more likely to experience a poor respiratory outcome (on average by 13.3 pp) than the people living in Ruda Śląska.

Table 2. Selected correlates of particular health outcomes and energy poverty (marginal effects)[12]

independent variable	dependent variable					
	pooled model			model limited to the energy poor sample		
	musculoskeletal	respiratory	cardiovascular	musculoskeletal	respiratory	cardiovascular
logarithm of placement on the subjective health scale	-0.179***	-0.062	-0.306***	-0.063	-0.158	-0.245***
	(0.062)	(0.096)	(0.061)	(0.069)	(0.120)	(0.092)
logarithm of equivalised income	-0.003	0.148**	-0.053	-0.104*	0.014	-0.068
	(0.051)	(0.062)	(0.036)	(0.054)	(0.084)	(0.056)
age	reference level: < 20					
21 - 40	0.023	-0.234***	-0.089	0.414***	-0.187	-0.162
	(0.084)	(0.072)	(0.086)	(0.151)	(0.118)	(0.132)
41 - 60	0.179**	-0.153*	0.026	0.613***	-0.133	-0.099
	(0.091)	(0.080)	(0.078)	(0.159)	(0.141)	(0.124)
> 60	0.216**	-0.213**	0.169**	0.594***	-0.170	0.179
	(0.091)	(0.096)	(0.081)	(0.160)	(0.169)	(0.121)
male	reference level: female					
	-0.037	-0.005	0.054**	0.012	0.031	0.084**
	(0.023)	(0.022)	(0.022)	(0.042)	(0.053)	(0.042)
Tychy	reference level: Ruda Śląska					
	0.043	0.133***	0.019	-0.040	0.208***	0.044
	(0.031)	(0.045)	(0.026)	(0.046)	(0.079)	(0.061)
year of building construction	reference level: before 1946					
1946-1960	-0.018	0.049	-0.020	-0.100	0.021	-0.049
	(0.043)	(0.066)	(0.037)	(0.073)	(0.103)	(0.082)

[11] People who are in better health (according to their individual placement on a subjective health scale) have a significantly lower risk of developing cardiovascular and musculoskeletal diseases (by more than 17 and 30 pp, respectively). The older the person is, the higher the person's risk of developing musculoskeletal and cardiovascular diseases.

[12] The estimates of remaining parameters are in the Appendix, table A5.

1961-1980	-0.057 (0.046)	0.046 (0.073)	0.003 (0.040)	-0.163* (0.086)	0.159 (0.114)	-0.039 (0.080)
after 1980	-0.178*** (0.062)	0.029 (0.083)	0.035 (0.045)	-0.424*** (0.151)	0.195 (0.163)	-0.009 (0.095)
ownership	reference level: outright ownership					
municipal	0.111*** (0.042)	-0.010 (0.064)	0.002 (0.038)	0.137* (0.076)	-0.015 (0.093)	0.011 (0.069)
housing association	0.031 (0.041)	0.060 (0.052)	0.043 (0.037)	0.007 (0.077)	0.092 (0.096)	0.068 (0.067)
heating system type	reference level: district heating					
coal / wood stove in the apartment	-0.132** (0.060)	0.054 (0.081)	-0.081 (0.050)	-0.217** (0.102)	0.279** (0.116)	-0.069 (0.083)
coal / wood stove in the boiler room	-0.120* (0.063)	-0.059 (0.082)	-0.132*** (0.040)	-0.198* (0.111)	0.156 (0.120)	-0.244*** (0.068)
gas / oil stove / other in the apartment / boiler room	-0.016 (0.058)	0.042 (0.079)	-0.047 (0.040)	-0.093 (0.086)	0.225** (0.100)	-0.104* (0.061)
	reference level: absence of given characteristic					
high actual energy costs	0.034 (0.041)	0.185*** (0.067)	-0.017 (0.033)	-	-	-
housing faults	0.106*** (0.035)	-0.054 (0.055)	0.060** (0.029)	-	-	-
adjusted R2	0.3954	0.129	0.4978	0.4652	0.1866	0.5012
number of observations	1,215	1,215	1,215	465	465	465

*Notes: standard errors clustered at the household level. *** p < 0.01, ** p < 0.05, * p < 0.1*

Source: own elaboration based on the survey data collected in Ruda Śląska and Tychy (n = 1,735)

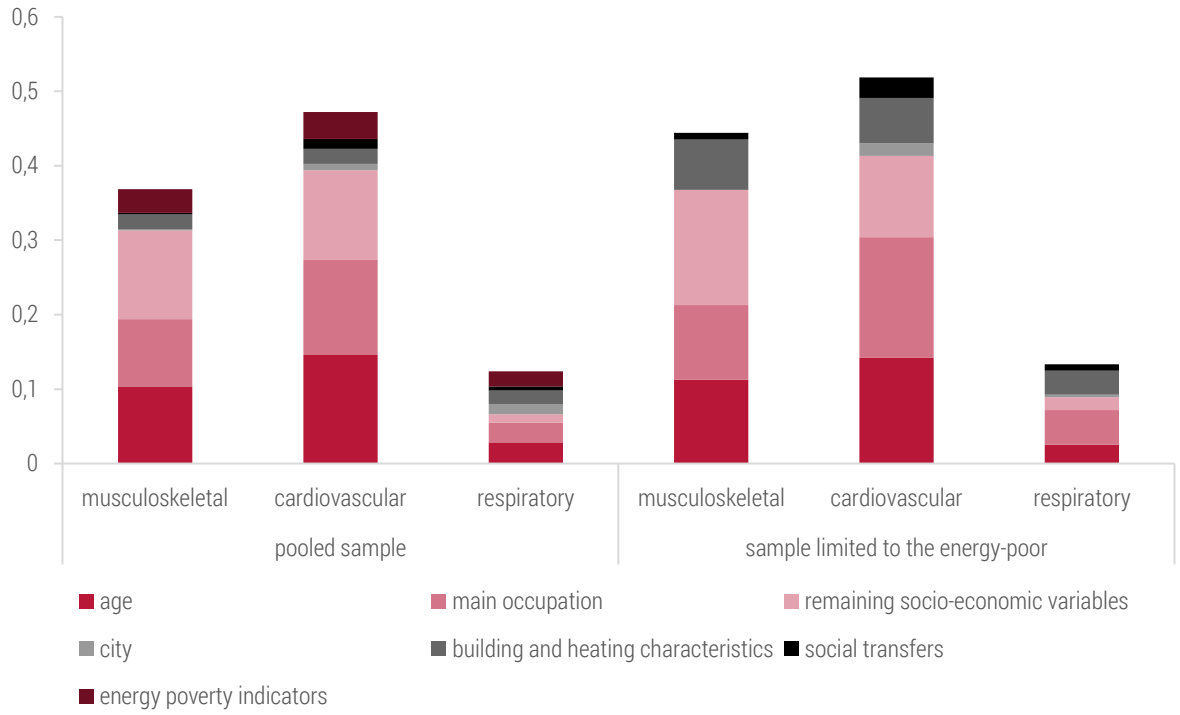
In order to assess the contribution of energy poverty (and other controls used in our models) to the differences in the likelihood of developing a given disease, we use the Shapley decomposition. In the pooled sample, the energy poverty risk is the third-most important factor behind the differences in the likelihood of poor health outcomes (Figure 8). About 16% of the explained variance in the probability of having poor respiratory outcomes is attributable to energy poverty indicators, compared to almost 9% and 8% in the case of developing musculoskeletal and cardiovascular disorders, respectively. Age and occupation contribute the most (on average around 50%) to the variance in the likelihood of developing each disease.

Building and heating characteristics also play an important role in the likelihood of developing a given disease. In the pooled sample, 15% of the variance in the probability of developing a respiratory disorder can be attributed to the differences in building and heating characteristics, while the variance in the likelihood of developing musculoskeletal and cardiovascular diseases due to these differences is 5% and 4%, respectively. However, among individuals who are energy-poor, this variance is larger, at 24% for respiratory diseases, 15% for musculoskeletal diseases, and 12% for cardiovascular diseases. In the pooled model (and its re-estimated version on the energy-poor sample), individual traits explain around 80% of the variance in the probability of having poor musculoskeletal and cardiovascular outcomes (and 50% for respiratory diseases).

Finally, the explained variance in the likelihood of developing respiratory disorders is lower than it is in the models for cardiovascular and musculoskeletal diseases. We speculate that this is because many respiratory diseases are infectious, and we could not control for a variety of factors associated with rates of infection and

transmission among individuals, such as humidity, temperature, seasonal changes in behaviour, or pre-existing immunity (Pica and Bouvier, 2012).[13]

Figure 8. Shapley decomposition of the probability of having a particular disease



Notes: We base the Shapely decomposition on the logistic regression model (1) and its results presented in Table 2.

Source: own elaboration based on the survey data collected in Ruda Śląska and Tychy (n = 1,735)

4. Summary and concluding remarks

In this paper, we have studied the relationship between energy poverty and poor health outcomes. We used data collected in a purposefully structured survey on a sample of 1,735 individuals (700 households) in two middle-sized cities in Poland located in the industrial and coal-dependent region of Upper Silesia. For the first time, we have studied the relationship between energy poverty and health in Central and Eastern European countries based on a detailed dataset that was designed and implemented with this aim in mind.

Our findings indicate that living in substandard housing conditions (mould, leaking roof) is related to a higher risk of developing musculoskeletal and cardiovascular diseases. We have highlighted a significant difference between the energy-poor and the non-poor population in their exposure to the risk of developing respiratory diseases. Among the energy-poor households, living in an apartment with a coal or a wood stove was found to be associated with a higher risk of developing respiratory diseases. This finding suggests that the use of inefficient stoves and fuel is associated with significantly higher levels of indoor air pollution, and, in turn, with

[13] This may be of particular importance as we collected the data during the three weeks of the flu season in Poland: there were almost 70,000 flu cases in Śląskie voivodship (2% of the population); the average daily incidence was 72 cases per 100,000 people.

a higher probability of developing respiratory disorders. Finally, we showed that having substandard living conditions (mould, leaking roof, etc.) is the most common energy poverty factor among people who reported having any disease.

Tackling energy poverty is a challenge for public policy, especially during the COVID-19 pandemic (Sokołowski, 2020). We suspect that the pandemic has caused the importance of the relationship between housing, environment, energy, and health to increase. Our study has contributed to the analytical background needed to formulate regional and local housing and heating policies. As possible interventions, we recommend that financial support for energy-efficient improvements that are likely to provide significant energy savings be targeted at energy-poor households. Based on our findings, we believe that connecting low-quality multifamily buildings to district heating would help to alleviate poor living conditions and improve the quality of life of people in energy poverty. Such interventions in the housing stock could positively affect public health (Poortinga et al., 2018) by reducing the risk of developing musculoskeletal and cardiovascular diseases. Better housing conditions would also improve the general quality of life of people in energy poverty, by, for example, lowering their spending on heating and increasing their disposable income that could be used to cover other expenses. Additionally, improving the efficiency of the heating sources used by the energy-poor population may lower their risk of developing respiratory disorders. Finally, our findings clearly show that energy-poor households tend to cluster in areas dominated by older municipal housing stock. These areas should be supported through urban renewal policies, as decreasing levels of energy poverty is in line with the social, economic and environmental aims of these urban interventions.

Our study has limitations. It is based exclusively on subjective health assessments. It is also a cross-sectional study, which does not allow us to draw conclusions about causality. However, our findings may serve as a pilot study that provides the basis for similar research. While we understand that our data are situated in the local context of two cities in Poland, we believe that our findings can offer valuable insights for policymakers seeking either to improve the living conditions of people in poverty, or to design transition policies aimed at reducing solid fuel consumption. Finally, we scheduled the fieldwork one month before the start of the pandemic crisis and the lockdown. On the one hand, our dataset does not take into account the effect of pandemic, or its relationship to energy poverty. On the other, our dataset may be helpful to researchers assessing the effects of the pandemic, especially if similar surveys are conducted in the future, or if our research is extended to further locations.

References

Adler N. E., Newman K. (2002). Socioeconomic disparities in health: pathways and policies. Health Aff (Millwood);21(2):60–76.

Agrawal S. (2012). Effect of indoor air pollution from biomass and solid fuel combustion on prevalence of self-reported asthma among adult men and women in India: findings from a nationwide large-scale cross-sectional survey. The Journal of asthma: official journal of the Association for the Care of Asthma 49(4), 355–365. https://doi.org/10.3109/02770903.2012.663030

Bierwiaczonek K. (2016). Społeczne znaczenie miejskich przestrzeni publicznych (The Social Importance of Urban Public Spaces), University of Silesia, Katowice.

Boardman B. (2010). Fixing Fuel Poverty: Challenges and Solutions. London: Earthscan.

Bouzarovski S., Thomson H. (2018). Energy Vulnerability in the Grain of the City: Toward Neighborhood Typologies of Material Deprivation, Annals of the American Association of Geographers 108(3), 695–717, https://doi.org/10.1080/24694452.2017.1373624

Bouzarovski S., Tirado Herrero S. (2017). Geographies of injustice: the socio-spatial determinants of energy poverty in Poland, the Czech Republic and Hungary, Post-Communist Economies, 29:1, 27-50, DOI: 10.1080/14631377.2016.1242257

Braubach, M., Ferrand, A. (2013). Energy efficiency, housing, equity and health. Int J Public Health 58, 331–332. https://doi.org/10.1007/s00038-012-0441-2

Brunner K. M., Spitzer M., Christanell A. (2012). Experiencing fuel poverty. Coping strategies of low-income households in Vienna/Austria, Energy Policy, Volume 49, pp. 53-59, ISSN 0301-4215, https://doi.org/10.1016/j.enpol.2011.11.076.

DECC. (2016). Affordable warmth & health impact evaluation toolkit. https://www.cse.org.uk/downloads/toolkits/fuel-poverty/affordable-warmth-and-health-evaluation-toolkit.pdf [Accessed 12th of October 2020]

Frankowski J., Tirado Herrero S. (2021), "What is in it for me?" A people-centered account of household energy transition co-benefits in Poland, Energy Research & Social Science, Volume 71, 101787, ISSN 2214-6296, https://doi.org/10.1016/j.erss.2020.101787.

Gilbertson J., Grimsley M., Green G., For the Warm Front Study Group (2012). Psychosocial routes from housing investment to health: Evidence from England's home energy efficiency scheme, Energy Policy 49, 22–43. https://doi.org/10.1016/j.enpol.2012.01.053

Goodman P. (2011). Fuel Poverty, Older People and Cold Weather: An All-Island Analysis, Report.

González-Eguino M. (2015). Energy poverty: An overview, Renewable and Sustainable Energy Reviews 47, 377–385, https://doi.org/10.1016/j.rser.2015.03.013

Grey C., Schmieder-Gaite T., Jiang S., Nascimento C., Poortinga W. (2017). Cold homes, fuel poverty and energy-efficiency improvements: a longitudinal focus group approach. Indoor and Built Environment 26, 902–913. https://doi.org/10.1177/1420326X17703450

Heyman B., Harrington B., Heyman A., The National Energy Action Research Group. (2011). A Randomised Controlled Trial of an Energy Efficiency Intervention for Families Living in Fuel Poverty, Housing Studies, 26:1, 117–132, DOI: https://doi.org/10.1080/02673037.2010.512787

Hulin M., Simoni M., Viegi G. (2012). Respiratory health and indoor air pollutants based on quantitative exposure assessments. The European Respiratory Journal 40, 1033–1045. https://doi.org/10.1183/09031936.00159011

Jessel S., Sawyer S., Hernández D. (2019). Energy, Poverty, and Health in Climate Change: A Comprehensive Review of an Emerging Literature. Frontiers in Public Health 7, 357. https://doi.org/10.3389/fpubh.2019.00357

Kahneman, D., Deaton, A. (2010). High income improves evaluation of life but not emotional well-being. Proceedings of the National Academy of Sciences of the United States of America, 107(38), 16489–16493. https://doi.org/10.1073/pnas.1011492107

Kahouli, S. (2020). An economic approach to the study of the relationship between housing hazards and health: The case of residential fuel poverty in France, Energy Economics 85, 104592. https://doi.org/10.1016/j.eneco.2019.104592

Kose T. (2019). Energy poverty and health: the Turkish case, Energy Sources, Part B: Economics, Planning, and Policy, 14(5), 201–213. https://doi.org/10.1080/15567249.2019.1653406

Krzysztofik R., Kantor-Pietraga I. Spórna T. (2020). Spatial and functional dimensions of the COVID-19 epidemic in Poland, Eurasian Geography and Economics, https://doi.org/10.1080/15387216.2020.1783337

Lacroix E., Chaton C. (2015). Fuel poverty as a major determinant of perceived health: the case of France, Public Health 129(5), 517–524. https://doi.org/10.1016/j.puhe.2015.02.007.

Laney, A. S., Weissman, D. N. (2014). Respiratory diseases caused by coal mine dust. Journal of occupational and environmental medicine, 56 Suppl 10(0 10), S18–S22. https://doi.org/10.1097/JOM

Lewandowski P., Kiełczewska A., Ziółkowska (Święcicka) K. (2018). Zjawisko ubóstwa energetycznego w Polsce, w tym ze szczególnym uwzględnieniem zamieszkujących w domach jednorodzinnych (Energy poverty among households living in the detached houses in Poland). IBS Research Report 02/2018.

Levin-Zamir D., Baron-Epel O. B., Cohen V., Elhayany A. (2016). The Association of Health Literacy with Health Behavior, Socioeconomic Indicators, and Self-Assessed Health From a National Adult Survey in Israel, Journal of Health Communication, 21:sup2, 61-68, DOI: 10.1080/10810730.2016.1207115

Liddell C., Morris Ch. (2010). Fuel poverty and human health: A review of recent evidence, Energy Policy 38(6), 2987–2997. https://doi.org/10.1016/j.enpol.2010.01.037

Llorca M., Rodríguez-Álvarez A., Jamasb T. (2020). Objective vs. subjective fuel poverty and self-assessed health. Energy Economics 87, 104736. https://doi.org/10.1016/j.eneco.2020.104736

Maidment Ch. D., Jones Ch. R., Webb T. L., Hathway E. A., Gilbertson J. M. (2014). The impact of household energy efficiency measures on health: A meta-analysis, Energy Policy 65, 583–593. https://doi.org/10.1016/j.enpol.2013.10.054

Muzioł-Węcławowicz A., Nowak K. (2018). Mieszkalnictwo społeczne. Raport o stanie polskich miast (Social Housing in Polish cities). Instytut Rozwoju Miast i Regionów, Kraków.

Niccoli T., Partridge L., (2012). Ageing as a Risk Factor for Disease, Current Biology 22(17), 741–752. https://doi.org/10.1016/j.cub.2012.07.024

OECD. (2013a). OECD Guidelines on Measuring Subjective Well-being. OECD Publishing, Paris, https://doi.org/10.1787/9789264191655-en.

OECD. (2013b). Framework for integrated analysis, [in:] OECD Framework for Statistics on the Distribution of Household Income, Consumption and Wealth, OECD Publishing, Paris. DOI: https://doi.org/10.1787/9789264194830-11-en

O'Sullivan K., Barnard L.T., Viggers H., Howden-Chapman P. (2016). Child and youth fuel poverty: assessing the known and unknown. People, Place Policy 10 (11), 77–87. https://doi.org/10.3351/ppp.0010.0001.0006

Oliveras L., Peralta A., Palència L., Gotsens M., López M. J., Artazcoz L., Borrell C., Marí-Dell'Olmo M., (2020). Energy poverty and health: Trends in the European Union before and during the economic crisis, 2007–2016, Health & Place, 102294. https://doi.org/10.1016/j.healthplace.2020.102294.

Ormandy D., Ezratty V. (2012). Health and thermal comfort: From WHO guidance to housing strategies, Energy Policy, Volume 49, pp. 116-121, ISSN 0301-4215, https://doi.org/10.1016/j.enpol.2011.09.003.

Oxlade O., Murray M. (2012). Tuberculosis and Poverty: Why Are the Poor at Greater Risk in India? PLoS ONE 7(11): e47533. https://doi.org/10.1371/journal.pone.0047533

Pica, N., & Bouvier, N. M. (2012). Environmental factors affecting the transmission of respiratory viruses. Current opinion in virology, 2(1), 90–95. https://doi.org/10.1016/j.coviro.2011.12.003

Pienimäki T. (2002). Cold exposure and musculoskeletal disorders and diseases. A review, International Journal of Circumpolar Health, 61:2, 173-182, DOI: 10.3402/ijch.v61i2.17450

Poortinga W., Jiang S., Grey C., Tweed C. (2018). Impacts of energy-efficiency investments on internal conditions in low-income households, Building Research & Information, 46:6, 653–667. https://doi.org/10.1080/09613218.2017.1314641

Preval N., Chapman R., Pierse N., Howden-Chapman P. (2010). Evaluating energy, health and carbon co-benefits from improved domestic space heating: A randomised community trial, Energy Policy 38(8), 3965–3972. https://doi.org/10.1016/j.enpol.2010.03.020

Recalde M., Peralta A., Oliveras L., Tirado-Herrero S., Borrell C., Palència L., Gotsens M., Artazcoz L., Marí-Dell'Olmo M. (2019). Structural energy poverty vulnerability and excess winter mortality in the European Union: Exploring the association between structural determinants and health, Energy Policy 133, 110869. https://doi.org/10.1016/j.enpol.2019.07.005

Shorrocks, A. F. (2013). Decomposition Procedures for Distributional Analysis: A Unified Framework Based on the Shapley Value. The Journal of Economic Inequality 11 (1): 99–126. https://doi.org/10.1007/s10888-011-9214-z.

Sokołowski J., Lewandowski P., Kiełczewska A. Bouzarovski S. (2020). A multidimensional index to measure energy poverty: the Polish case, Energy Sources, Part B: Economics, Planning, and Policy 15(2), 92–112. https://doi.org/10.1080/15567249.2020.1742817

Sokołowski J., Frankowski J. (2020). Ubóstwo energetyczne w województwie łódzkim (Energy poverty in Łódzkie Voivodeship). Regional Centre for Social Policy in Łódź, Łódź.

Sokołowski, M. M. (2020). Regulation in the COVID-19 pandemic and post-pandemic times: day-watchman tackling the novel coronavirus. Transforming Government: People, Process and Policy. DOI (10.1108/TG-07-2020-0142)

Statistics Poland (GUS). (2018a). Household Budget Study, 2017.

Statistics Poland (GUS). (2018b). Local Data Bank.

Statistics Poland (GUS). (2019). Energy Consumption in Households in 2018, https://stat.gov.pl/download/gfx/portalinformacyjny/pl/defaultaktualnosci/5485/2/4/1/zuzycie_energii_w_gospodarstwach_domowych_w_2018.pdf [Accessed: 8th of October 2020]

Sýkora, L., & Bouzarovski, S. (2012). Multiple Transformations: Conceptualising the Post-communist Urban Transition. Urban Studies, 49(1), 43–60. https://doi.org/10.1177/0042098010397402

Szweda A. (2018). Identyfikacja i ocena stanu zachowania osiedli i kolonii robotniczych w Rudzie Śląskiej (Identification and assessment of the condition of workers' estates and settlements in Ruda Śląska). Prace Komisji Krajobrazu Kulturowego, 40(2): 173–188. https://doi.org/10.30450/201817

Tang, K. L., Rashid, R., Godley, J., & Ghali, W. A. (2016). Association between subjective social status and cardiovascular disease and cardiovascular risk factors: a systematic review and meta-analysis. BMJ open, 6(3), e010137. https://doi.org/10.1136/bmjopen-2015-010137

Thomson H., Bouzarovski S., Snell C. (2017b). Rethinking the measurement of energy poverty in Europe: a critical analysis of indicators and data. Indoor and Built Environment 26 (7), 879–901. https://doi.org/10.1177/1420326X17699260

Thomson H., Snell C., Bouzarovski S. (2017a). Health well-being and energy poverty in Europe: a comparative study of 32 European countries. International Journal of Environmental Research and Public Health 14(6), 584. https://doi.org/10.3390/ijerph14060584

Thomson H., Simcock N., Bouzarovski S., Petrova S. (2019). Energy poverty and indoor cooling: An overlooked issue in Europe. Energy and Buildings 196(1): 21–29. https://doi.org/10.1016/j.enbuild.2019.05.014

Thomson H, Thomas S. (2014). Developing empirically supported theories of change for housing investment and health. Soc Sci Med. 2015 Jan;124:205-14. doi: 10.1016/j.socscimed.2014.11.043. PMID: 25461878; PMCID: PMC4292981.

Weston, E., Nasarwanji, M. F., Pollard, J. P. (2016). Identification of Work-Related Musculoskeletal Disorders in Mining. Journal of safety, health and environmental research, 12(1), 274–283.

WHO (2018a). Housing and health guidelines. Geneva: World Health Organization; Licence: CC BY-NC-SA 3.0 IGO.

WHO (2018b). WHO Global Ambient Air Quality Database by country and city (update 2018). Available at: https://www.who.int/airpollution/data/cities/en/

Wu X., Rachel C. Nethery, Benjamin M. Sabath, Danielle Braun, Francesca Dominici (2020). Exposure to air pollution and COVID-19 mortality in the United States: A nationwide cross-sectional study, medRxiv (preprint). https://doi.org/10.1101/2020.04.05.20054502

Zhang D., Li J., Han P., (2019). A multidimensional measure of energy poverty in China and its impacts on health: An empirical study based on the China family panel studies, Energy Policy 131, 72–81. https://doi.org/10.1016/j.enpol.2019.04.037

Appendix

A1. Descriptive statistics of selected variables in the sample

City	Frequency	%
Ruda Śląska	895	51.59
Tychy	840	48.41
Gender	**Frequency**	**%**
Women	913	52.62
Man	822	47.38
Type of building	**Frequency**	**%**
Detached house	769	44.27
Multifamily building	967	55.73
Year of building construction	**Frequency**	**%**
Before 1945	278	16.02
1946-1960	415	39.04
1961-1980	738	42.54
After 1981	304	17.52
Main heating source	**Frequency**	**%**
District heating	709	40.86
Coal / wood stove in the apartment	253	14.58
Coal / wood stove in the boiler room	524	30.2
Gas / oil stove / other	249	14.35
Main occupation	**Frequency**	**%**
Employed	848	48.88
Unemployed	113	6.51
Student	250	14.41
Retired / pensioner	404	23.29
Social transfer beneficiary	120	6.92
Age	**Frequency**	**%**
0-20	342	19.71
21-40	515	29.68
41-60	496	28.59
60 and more	382	22.02
Monthly income	**Mean**	**SD**
	3681.11	3502.46

Source: own elaboration based on the survey data collected in Ruda Śląska and Tychy (n = 1,735)

A2. Weighting procedure

We used population weights based on information from the Statistics Poland for 2018 (the most recent available information at the time of writing). We weighted the composition of our sample with the shares of age groups and gender in Ruda Śląska and Tychy. Next, we re-weighted the sample according to the shares of households with different numbers of adults and children in Śląskie voivodship.

A3. Correlations between specific health indicators

Respiratory	Confirmed by a physician	Self-diagnosed	Doctor's appointment (last 12 months)
Self-diagnosed	-0.1215		
Doctor's appointment (last 12 months)	0.6365	0.0028	
Hospital visit (last 12 months)	0.0858	0.045	0.1042
Musculoskeletal	Confirmed by a physician	Self-diagnosed	Doctor's appointment (last 12 months)
Self-diagnosed	-0.0904		
Doctor's appointment (last 12 months)	0.7318	0.0145	
Hospital visit (last 12 months)	0.3207	-0.0053	0.4129
Cardiovascular	Confirmed by a physician	Self-diagnosed	Doctor's appointment (last 12 months)
Self-diagnosed	-0.0470		
Doctor's appointment (last 12 months)	0.8172	0.0771	
Hospital visit (last 12 months)	0.3423	0.0790	0.3826

Source: own elaboration based on the survey data collected in Ruda Śląska and Tychy (n = 1,735)

A4. Selected correlates of particular health outcomes and energy poverty (marginal effects)

independent variable	dependent variable					
	pooled model			model limited to the energy poor sample		
	musculoskeletal	respiratory	cardiovascular	musculoskeletal	respiratory	cardiovascular
reference level: unemployed						
manager / professional	-0.028 (0.074)	-0.063 (0.088)	-0.007 (0.055)	0.185* (0.102)	-0.116 (0.140)	0.079 (0.118)
technician / clerical support	-0.038 (0.061)	-0.069 (0.085)	-0.021 (0.052)	-0.285** (0.133)	-0.520*** (0.158)	-0.106 (0.129)
services	-0.003 (0.051)	-0.100 (0.087)	-0.000 (0.054)	0.021 (0.092)	-0.410*** (0.136)	0.066 (0.107)
craft	-0.158*** (0.061)	-0.049 (0.107)	0.020 (0.047)	-0.235** (0.093)	-0.171 (0.132)	0.053 (0.075)
machines / elementary	0.043 (0.055)	-0.115 (0.090)	-0.139* (0.072)	-0.025 (0.080)	-0.122 (0.110)	-0.205* (0.124)
school / university student	-0.065 (0.103)	0.035 (0.096)	-0.181* (0.098)	0.060 (0.181)	-0.005 (0.145)	-0.295 (0.182)
retired or pensioner	0.103* (0.053)	0.058 (0.099)	0.026 (0.048)	0.212** (0.089)	-0.023 (0.131)	-0.005 (0.076)
beneficiary of a social transfer	-0.047 (0.107)	0.046 (0.110)	-0.109 (0.100)	0.314* (0.171)	-0.155 (0.167)	-0.069 (0.142)
reference level: single-family building						
multifamily building	-0.074 (0.066)	0.133* (0.071)	-0.046 (0.043)	-0.070 (0.104)	0.211* (0.109)	-0.022 (0.064)
logarithm of floor area	0.029 (0.042)	0.063 (0.054)	0.019 (0.032)	0.064 (0.066)	0.090 (0.082)	0.024 (0.055)
reference level: wooden building						
concrete / panel building	0.020	-0.134	-0.056	0.067	-0.296*	-0.043

	(0.071)	(0.089)	(0.056)	(0.111)	(0.165)	(0.092)
building made of bricks	0.019	-0.134	0.030	0.086	-0.150	0.023
	(0.062)	(0.083)	(0.047)	(0.094)	(0.149)	(0.083)
	reference level: absence of given characteristic					
uninsulated house	-0.035	0.072	-0.013	-0.071	-0.046	-0.012
	(0.030)	(0.047)	(0.021)	(0.057)	(0.078)	(0.042)
leaking windows/doors	0.090**	0.102	0.012	0.009	0.183**	-0.072
	(0.040)	(0.075)	(0.039)	(0.062)	(0.084)	(0.066)
unventilated house	0.078*	0.035	0.012	0.064	-0.002	-0.032
	(0.047)	(0.074)	(0.047)	(0.062)	(0.084)	(0.075)
beneficiary of housing / energy / heating / coal allowance	-0.035	-0.132*	0.111***	-0.059	-0.151	0.091*
	(0.046)	(0.075)	(0.034)	(0.067)	(0.092)	(0.053)
beneficiary of social / unemployed allowance / charity	0.022	0.045	-0.100***	0.138*	-0.065	-0.063
	(0.041)	(0.061)	(0.036)	(0.081)	(0.081)	(0.058)
beneficiary of coal allowance	-0.098	-0.103	0.067*	-0.130	-0.099	0.064
	(0.065)	(0.079)	(0.038)	(0.102)	(0.100)	(0.072)
low income high cost	0.024	0.058	0.022	-	-	-
	(0.041)	(0.063)	(0.035)			
difficulties paying bills	0.008	-0.017	-0.012	-	-	-
	(0.047)	(0.089)	(0.047)			
inadequate thermal comfort	-0.017	0.041	-0.161***	-	-	-
	(0.049)	(0.071)	(0.041)			
adjusted R2	0.3954	0.129	0.4978	0.4652	0.1866	0.5012
number of observations	1,215	1,215	1,215	465	465	465

*Notes: standard errors clustered at the household level. *** p < 0.01, ** p < 0.05, * p < 0.1*

Source: own elaboration based on the survey data collected in Ruda Śląska and Tychy (n = 1,735)

www.ibs.org.pl