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Energy poverty and health: Trends in the European Union before and during the economic crisis, 2007–2016

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A B S T R A C T

The aim of this study is to analyse the time trends in the European Union (EU) before and during the economic crisis in 1) the energy poverty (EP) prevalence; 2) the association between EP and health and 3) the impact of EP on health. We analyse trends among women and men in two EU macro regions, defined by a novel index of structural vulnerability to EP. The study shows how EP and its impact on health worsened during the economic crisis and identifies groups at higher risk such as women and people living in Mediterranean and Eastern European countries, which have been found to be countries with higher structural vulnerability to EP.

1. Introduction

Energy for cooking, lighting, washing or achieving thermal comfort at home is one of the essential elements of adequate housing, which is recognized as a human right by the United Nations (Office of the United Nations, 2009). Energy poverty (EP) can be understood as the inability of a household to secure a socially and materially required level of energy services in the home (Bouzarovski, 2014). The main driver of EP is the interaction of high energy prices, energy-inefficient homes and appliances, low household incomes, and the specific energy needs of the household. These drivers are themselves embedded in more structural determinants such as energy, housing and labour policies and markets, economic policies, and welfare states (Bouzarovski, 2014; Csiba et al., 2016; Marí-Dell'Olmo et al., 2017). A broader and more dynamic conceptualisation of EP is energy vulnerability, which refers to the susceptibility of a household to experience EP if there is a change in the internal conditions of the dwelling unit (such as a loss of employment) or in the external conditions (such as an economic crisis). In this case, EP can be considered as a temporary result of deprivation, meaning that households can enter and exit the condition at specific moments (Tirado Herrero et al., 2016). Another relevant concept is structural vulnerability to EP, which refers to the political and socio-economic conditions of the countries which determine the degree of protection that states provide to its population in the case of changes in the internal or external conditions that may drive households into EP. Structural vulnerability to EP is therefore closely associated with the percentage of people suffering from EP in the countries (Recalde et al., 2019).

EP is a major social problem in Europe and is likely to further increase in the coming years due to rising energy prices, continuing economic hardship, increasing inequalities, and greater climate variability due to climate change (Bouzarovski, 2014; Csiba et al., 2016; EPEE, 2009; Marmot Review Team, 2011). It is estimated that EP affects between 50 and 125 million people in Europe (EPEE, 2009). Specifically, in 2014, 10.2% of households in the European Union (EU) were unable to keep their home adequately warm during the cold months (Tirado Herrero et al., 2016). However, as several studies have shown, EP is not equally distributed socially and geographically. Socially, above-average rates of EP are experienced by the elderly, families with children (especially single parent families), households with people with disabilities or long-term illnesses, the unemployed, and people in poorly paid jobs (Bouzarovski, 2014; Csiba et al., 2016; EPEE, 2009; Hernández, 2016; Gillard et al., 2017; Wright, 2004; Adam and Monaghan, 2016; O'sullivan et al., 2016). Geographically, EP is far more important in Mediterranean and Eastern EU Member States, than in the

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Central and Northern ones (Bouzarovski, 2014; Bouzarovski and Tirado Herrero, 2017; Bouzarovski, 2018; Bollino and Botti, 2017). By analysing spatial trends in EP at the national level, Bousarovski and Tirado Herrero identified two differentiated macro regions in the EU, which they called the core and the periphery (Bouzarovski and Tirado Herrero, 2017). Going one step further, Recalde et al. studied the structural vulnerability of the EU-27 countries through the creation of an index that considers the structural determinants of EP, including indicators such as the countries expenditure on social protection per inhabitant, the median income, the percentage of social rental stock or the annual electricity switching rate. Through a cluster analysis of the index, that study identified exactly the same two macro regions as Bousarovski and Tirado Herrero, with the countries constituting the core being those with lower structural vulnerability to EP and those identified as belonging to the periphery being those with higher structural vulnerability to EP (Recalde et al., 2019).

Several studies and reports have documented how EP negatively affects people's health and well-being (Csiba et al., 2016; Marí-Dell'Olmo et al., 2017; Marmot Review Team, 2011; Hernández, 2016; Thomson et al., 2017a; Bosch et al., 2019; Healy, 2003; Liddell and Morris, 2010; Liddell and Guiney, 2015; Peralta et al., 2017; Poortinga et al., 2017). So far, most studies have focused on the direct and indirect health effects of cold housing, with little evidence on other consequences of EP such as inadequate household temperature during the hot months. The direct health effects of EP can be divided into increased morbidity rates and a higher risk of mortality. Cold temperatures are strongly related to cardiovascular and respiratory diseases, and double the risk of respiratory problems in children (Marmot Review Team, 2011). Cold also supresses the immune system, increasing the risk of infections and minor illnesses such as colds and flu (Liddell and Morris, 2010). Living in EP also exacerbates existing conditions such as arthritis and rheumatism and negatively affects mental health by increasing the financial stress on households. The most extreme EP-related health outcome is mortality, which has been studied through comparison of excess winter mortality across European countries (Healy, 2003). Among indirect health impacts, the main findings are that EP impairs children's educational attainment, emotional well-being and resilience, reduces dietary opportunities and choices, and increases the risk of accidents and injuries at home (Marmot Review Team, 2011). EP also hampers normal functioning in everyday areas such as work or study and has social consequences such as stigmatisation and reduction in social interaction. In addition, some groups are especially vulnerable to the effects of EP, such as the elderly, children, and dependent or chronically ill people (Thomson et al., 2013). In such cases, individual vulnerability is related to the larger number of hours spent at home. Moreover, the impacts of EP can be aggravated by other situations of vulnerability, such as a lack of social support (Marí-Dell'Olmo et al., 2017).

Structural determinants and drivers of EP have been directly affected by the economic crisis that started in 2008 in Europe and the consequent implementation of austerity packages, which may have led energy vulnerable households to go into EP. As some studies have shown, EP increased considerably during the economic crisis in countries such as Greece (Dagoumas and Kitsios, 2014) and Spain (Tirado Herrero et al., 2016; Tirado Herrero and Jiménez Meneses, 2016). Although recessions pose risks to health, the interaction of fiscal austerity with economic shocks and weak social protection is what ultimately seems to escalate health and social crises in Europe (Karanikolos et al., 2013). However, despite the rising importance of EP in European policy and science agendas, there is a lack of in-depth research on the trend in EP before and during the economic crisis at the European level, as well as on the possible aggravation of its health effects. Although some studies have shown that EP is associated with worse health outcomes, no studies have analysed the magnitude of this public health problem, that is, its impact at the population level.

The aim of this study was to fill this knowledge gap by analysing the time trend in the EU before and during the economic crisis in 1) the EP prevalence; 2) the association between EP and health; and 3) the impact of EP on health. We analysed trends among women and men in the two EU macro regions, defined by the degree of structural vulnerability to EP. We calculated two different epidemiological measures, since association measures allow us to know how EP and health are related and impact measures tell us to what extent EP is an important public health problem (Gefeller, 1990).

2. Methods

2.1. Design, study population, units of analysis, and information sources

This individual-based trends study analysed three cross-sectional waves of the European Quality of Life Surveys, corresponding to the years 2007, 2012, and 2016 (European Foundation for the Improvement of Living and Working Conditions, 2018a). It covers 95 940 individuals (aged 18 years or older) from the 27 European countries constituting the EU in the period 2007–2013 (EU27). The country samples are nationally representative and range from 1000 to 3000 respondents per year, depending on country size (European Foundation for the Improvement of Living and Working Conditions, 2018b).

2.2. Study variables

We included three health outcomes as dependent variables. To assess general health, we used self-reported health status measured by a single item with five response categories that we dichotomised into two: good self-reported health (when very good and good) and poor self-reported health (when fair, bad, and very bad) (Quesnel-Vallée, 2007). To measure subjective psychological well-being, we used the 5-item World Health Organisation Well-being Index, which scores each item on a scale from 0 to 5 and the sum of the five-item score is multiplied by 4, to give a final score ranging from 0 to 100. Higher scores indicate better well-being. We created two dichotomous variables through the application of two commonly used cut-off scores recommended to identify people with reduced well-being (score<50) and clinical depression (score<28) (Topp et al., 2015).

The main independent variables were EP and time. The EP assessment was based on the consensual approach, consisting of subjective self-reported indicators. To capture wider expression of EP, we included two different indicators. The first indicator considers individuals to experience EP if they report that they cannot afford to keep their homes adequately warm and the second one, if they report one or more arrears in utility bills such electricity, water, or gas during the past 12 months. From here on we will designate the first indicator as EP_T (where T stands for Temperature), and the second as EP_A (where A stands for Arrears).

Regarding time, we included the three last waves of the European Quality of Life Surveys, which correspond to the years before (2007) and during the crisis (2012 and 2016).

The stratification variables were sex and country typologies. We used the two macro regions proposed by Recalde et al., which divided the 27 EU member countries into two groups depending on their structural vulnerability to EP: (1) countries with lower structural vulnerability (LSVc) (Denmark, Netherlands, Sweden, Germany, Finland, Austria, Luxembourg, Belgium, France, United Kingdom, and Ireland) and (2) countries with higher structural vulnerability (HSVc) (Czech Republic, Malta, Slovenia, Portugal, Spain, Poland, Cyprus, Estonia, Hungary, Slovakia, Italy, Lithuania, Latvia, Greece, Bulgaria, and Romania). Age was considered as an adjustment variable.

2.3. Data analysis

To describe the study sample, we calculated the prevalence (percentage) of EP and the prevalence of health outcomes among people living with and without EP and performed chi-square tests to assess

whether the prevalence changed over time.

We analysed the association between EP and health through age-adjusted prevalence ratios (PR) and their 95% confidence intervals (CI), obtained by fitting Poisson regression models with robust variance (Espelt et al., 2017; Barros and Hirakata, 2003). The dependent variables were health outcomes, and the independent variables were EP, age, and year. To estimate changes in the association over time, we included the interaction between EP and survey year in the models and calculated PRs and CIs for each year.

Finally, as a measure of impact, we calculated the population attributable risk percent (PAR%), that is, the proportion of negative health outcomes (e.g. poor self-reported health) in the population that is attributable to EP and that, theoretically, could be prevented by eliminating EP. Measures of impact are important, because they take into account the proportion of individuals exposed to the risk factor in the population, and not only the strength of the association between the risk factor and the outcome. We obtained age-adjusted PAR% for each year directly from Poisson regression models by subtracting the expected cases if EP were absent from the observed cases and dividing these by the observed cases (Gefeller, 1990; Rückinger et al., 2009). To estimate changes over time, we calculated the PAR% differences between years. For both PAR% and PAR% differences, the bootstrap resampling method was used to calculate their respective 95% CI.

All analyses were performed for the three health outcomes separately for both EP indicators, and were stratified by sex, country typologies, and year. In all analyses we took into consideration the complex sample design by using sampling weights. We used the R software (version 3.4.4, R Foundation for Statistical Computing).

2.4. Supplementary analyses

As a sensitivity analysis, we repeated all the analyses, selecting the individuals in each country that were in the lowest income quartile. Income quartiles were based on equivalised household income in purchasing power parities in euros, which make countries comparable. We also ran the analyses by country. Country-specific results can be found in the supplementary information (S5 to S17).

3. Results

Of the 95 940 included individuals, 51.8% are women and 53.3% are citizens of LSVc. Below, the results are presented separately for the two EP indicators, EP_T and EP_A, respectively.

3.1. Inability to keep home adequately warm (EP_T)

3.1.1. Prevalence of energy poverty

Descriptive statistics for EP and health outcomes stratified by sex, region, and year are provided in Table 1. In the EU, 9.0% of the population could not afford to keep their homes adequately warm in 2007. This percentage rose to 11.8% in 2012 and decreased to 9.0% in 2016. This clear "peak" pattern (Λ) over time, in which EP increased from 2007 to 2012 and decreased between 2012 and 2016 was observed in all groups, independently of sex and region (Fig. 1a). Throughout the study period, EP_T was noticeably higher in HSVc than in LSVc and women experienced also higher EP_T rates than men. The most affected population was therefore women living in HSVc, where EP_T was 16.0%, 18.3%, and 14.8% in 2007, 2012, and 2016, respectively.

3.1.2. Association between energy poverty and health

The association between health outcomes and EP_T is shown in Fig. 2 (subfigures a-c). Detailed data can be found in the supplementary information (S1). We found an overall statistically significant association between the three health outcomes and EP_T, but the strength of the association varied depending on the different health indicators and was also affected by sex, region, and time.

The health outcome most strongly associated with EP_T was depression. Although not statistically significant, PR values were generally higher for LSVc than for HSVc in all three indicators. For example, in LSVc, women with EP_T had 3.24 (CI: 2.24–4.33) times more depression than those without EP_T in 2007 and in the case of men, in 2012 those with EP_T had 4.16 (CI:3.14–5.50) times more depression than those

Table 1
Weighted prevalence (%) of energy poverty and health outcomes by energy poverty over time stratified by sex and region.

	Women									Men								
	EU27			LSV			HSV			EU27			LSV			HSV		
	2007	2012	2016	2007	2012	2016	2007	2012	2016	2007	2012	2016	2007	2012	2016	2007	2012	2016
Cannot afford to keep home adequately warm (n)	**10.0** (2199)	**12.8** (3033)	**9.4** (1850)	**4.8** (325)	**7.9** (574)	**4.8** (327)	**16.0** (1874)	**18.3** (2459)	**14.8** (1523)	**7.9** (1315)	**10.8** (1728)	**8.5** (1132)	**4.5** (191)	**6.7** (340)	**5.2** (239)	**11.9** (1124)	**15.5** (1388)	**12.3** (893)
Poor self-reported health																		
Energy poverty	55.6	57.2	53.6	49.5	56.2	47.0	57.6	57.8	56.1	46.6	49.3	45.8	41.3	49.8	33.9	48.9	49.0	51.8
No energy poverty	**34.1**	**36.5**	**31.7**	**32.3**	**35.4**	**29.5**	**36.4**	**38.0**	**34.6**	**27.6**	**30.3**	**25.5**	**27.8**	**30.8**	**24.4**	**27.3**	**29.6**	**26.9**
Reduced well-being																		
Energy poverty	46.0	46.7	44.3	38.2	47.3	45.8	48.8	46.3	43.7	37.0	41.4	37.8	31.5	41.2	29.3	39.4	41.4	42.0
No energy poverty	25.0	24.8	23.5	**21.8**	**24.6**	**22.9**	**29.2**	**25.2**	**24.3**	**19.6**	**19.5**	**16.0**	**17.0**	**19.5**	**14.7**	**23.0**	**19.6**	**17.7**
Likely depression																		
Energy poverty	22.0	20.0	21.7	21.1	20.9	21.5	22.4	19.6	21.8	16.5	20.4	15.3	15.6	22.4	11.4	17.0	19.4	17.3
No energy poverty	8.3	8.1	8.0	6.6	7.8	7.6	**10.6**	**8.5**	**8.6**	6.0	5.7	5.2	5.0	5.5	4.7	**7.3**	**6.0**	**5.8**
Arrears in utility bills during the past 12 months (n)	**13.1** (2245)	**15.2** (3056)	**9.8** (1799)	**9.1** (623)	**10.2** (785)	**5.8** (407)	**17.7** (1622)	**20.9** (2271)	**14.5** (1392)	**12.1** (1431)	**15.1** (2009)	**9.1** (1188)	**9.9** (458)	**10.3** (564)	**5.9** (307)	**14.6** (973)	**20.6** (1445)	**12.9** (881)
Poor self-reported health																		
Energy poverty	47.9	45.4	44.5	47.6	43.2	37.7	48.1	46.6	47.7	37.2	38.9	40.2	34.5	39.4	29.6	39.4	38.6	46.0
No energy poverty	**34.7**	**38.3**	**32.7**	**31.9**	**36.4**	**29.9**	**38.3**	**40.8**	**36.2**	**28.2**	**31.2**	**26.1**	**27.8**	**31.2**	**24.7**	**28.5**	**31.3**	**27.8**
Reduced well-being																		
Energy poverty	**42.9**	**37.9**	**43.5**	38.9	36.7	43.2	**45.3**	**38.6**	**43.7**	34.0	34.1	35.2	29.8	34.4	26.5	37.4	34.0	39.7
No energy poverty	**25.0**	**25.8**	**23.6**	**21.0**	**25.2**	**22.8**	**29.9**	**26.7**	**24.5**	**19.1**	**19.8**	**16.1**	**16.2**	**19.5**	**14.7**	**22.6**	**20.2**	**17.9**
Likely depression																		
Energy poverty	**20.4**	**15.4**	**20.4**	15.8	14.3	20.6	23.2	16.0	20.3	15.9	13.9	14.8	16.6	14.0	11.7	15.4	13.9	16.4
No energy poverty	8.2	8.7	8.2	**6.5**	**8.3**	**7.6**	10.4	9.2	8.9	5.6	6.1	5.2	**4.2**	**5.8**	**4.6**	7.2	6.4	5.9

LSV: countries with lower structural vulnerability; HSV: countries with higher structural vulnerability. In parentheses, number of cases; in bold if chi-square test assessing change over time of prevalence is statistically significant (p-value < 0.05).

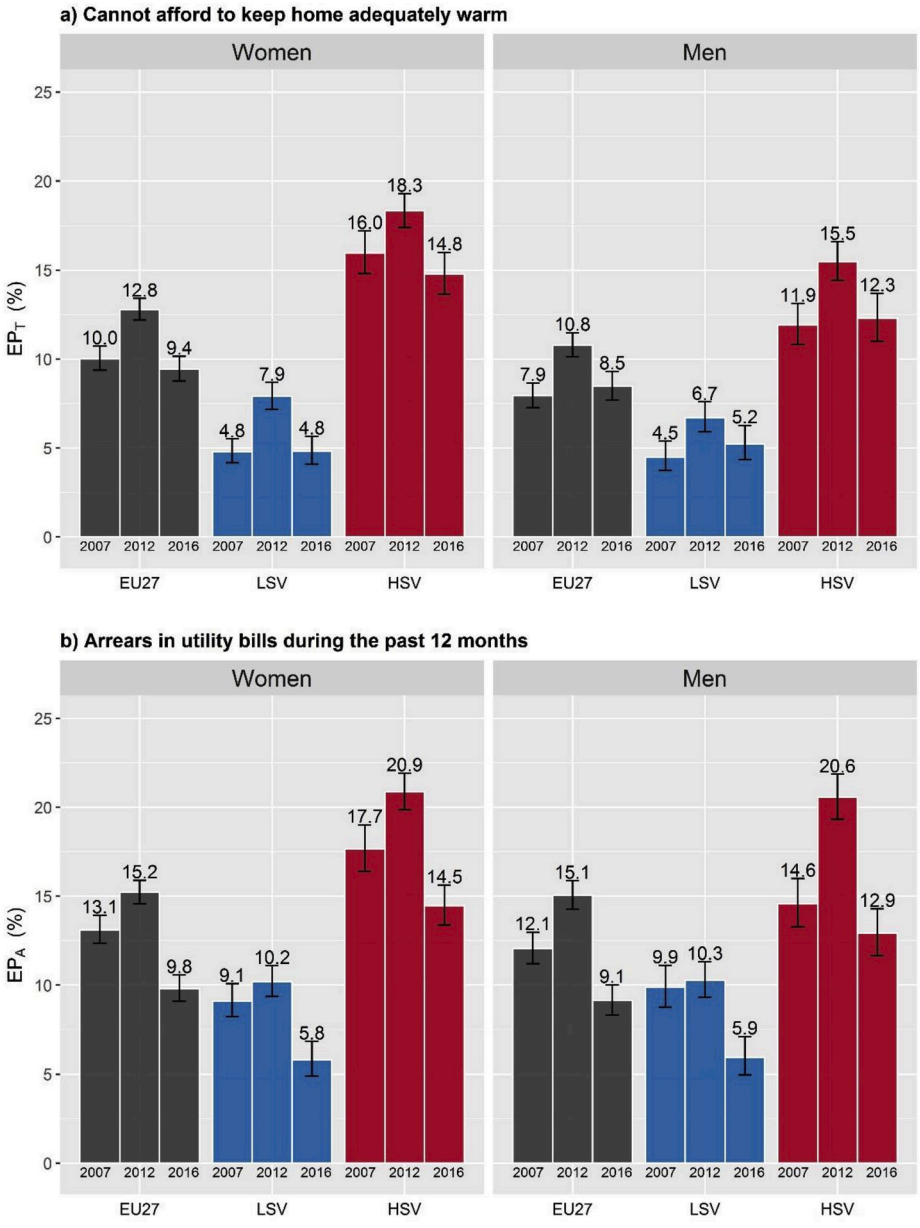

Fig. 1. Energy poverty prevalence over time stratified by sex and region.
EP_T: Energy poverty indicator "Cannot afford to keep home adequately warm; EP_A: Energy poverty indicator "One or more arrears in utility bills during the past 12 months"; LSV: countries with lower structural vulnerability; HSV: countries with higher structural vulnerability. Chi-square tests assessing change over time of EP percentage is statistically significant (p-value<0.05) in all cases.

without EP_T (subfigure 2c). Regarding the time trend, from 2007 to 2012, point estimates generally showed an increase in the strength of the association between the selected health indicators and EP_T, which was more marked in reduced well-being and depression in men in HSVc, where the increase was statistically significant (subfigures 2b-c, p-value of the year interaction were 0.011 and 0.02 respectively). Between 2012 and 2016, PRs tended to decrease in men in LSVc, but tended to remain stable or increase in men in HSVc and women in both LSVc and HSVc.

3.1.3. Population impact of energy poverty on health

The PAR% to EP_T of the three health outcomes are also shown in Fig. 2 (subfigures d-f). Detailed data can be found in the supplementary data (S2). EP_T significantly affected the population's health and this impact was clearly stronger in HSVc than in LSVc. For example, in 2012, the proportion of cases of depression due to EP_T was 15.46% (CI: 10.90%–20.35%) in men living in LSVc and 29.87% (CI: 23.84%–36.30%) in those living in HSVc. In women, this proportion in the two macro regions was 11.17% (CI: 7.94%–14.75%) and 21.28% (CI: 16.73%–236.37%), respectively (subfigure 2f).

We observed a clear tendency over time, as the PAR%s increased between 2007 and 2012 and decreased between 2012 and 2016. This "peak" pattern became more evident in reduced well-being (subfigure 2e) and even more so in depression (subfigure 2f), and particularly in HSVc, where differences between years were generally statistically significant (S2).

3.2. Arrears in utility bills during the past 12 months (EP_A)

3.2.1. Prevalence of energy poverty

The prevalence of EP_A stratified by sex, region and year is shown in Fig. 1b. Overall, the proportion of people experiencing EP was higher when we used the EP_A indicator. Again, HSVc and women were more affected by EP_A. Regarding time trends, although we still identified a "peak" pattern (Λ) over time in all cases, the EP_A increase between 2007 and 2012 in LSVc was less marked, but the decrease between 2012 and 2016 was still pronounced.

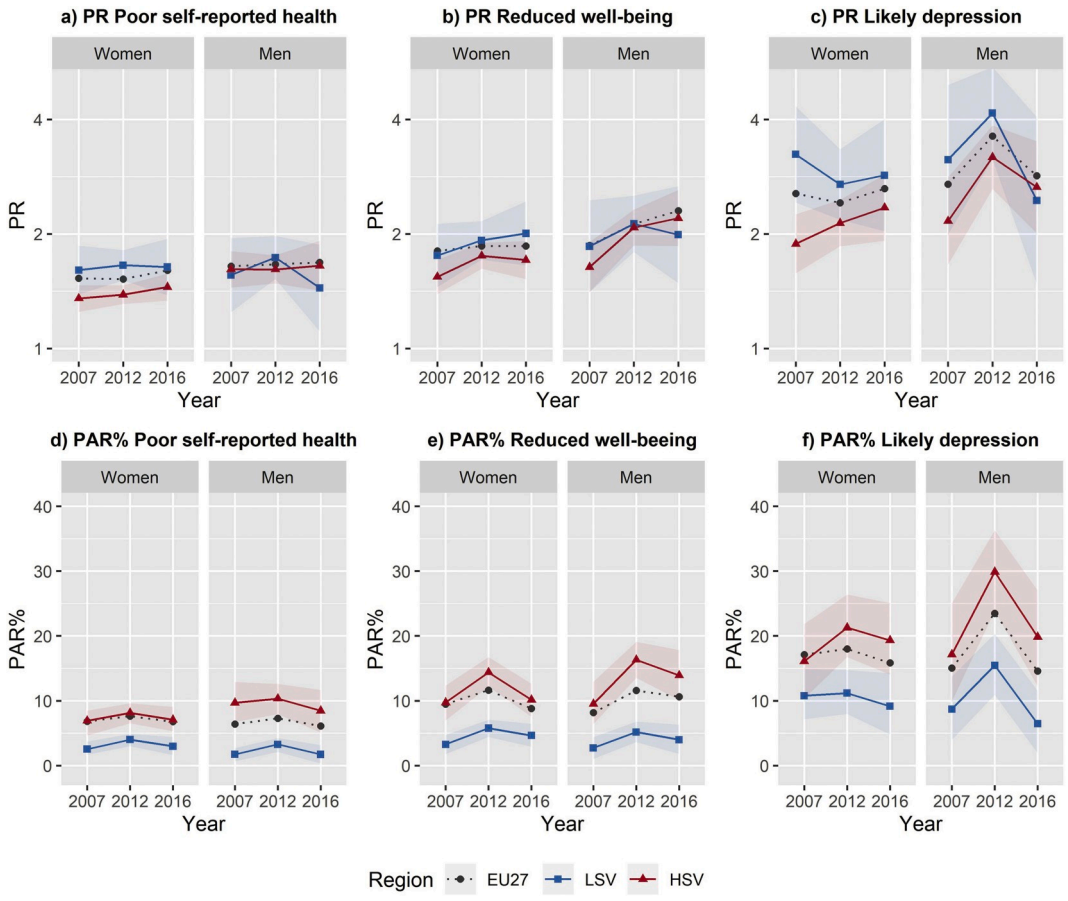

Fig. 2. Age-adjusted prevalence ratio (PR) of poor self-reported health status, reduced well-being and likely depression in people with EP_T versus people without EP_T over time and respective age-adjusted population attributable risk percent (PAR%) of the three health outcomes. Results are stratified by sex and region.
EP_T: energy poverty indicator "Cannot afford to keep home adequately warm; PR: age-adjusted prevalence ratio; PAR%: age-adjusted population attributable risk percent; LSV: countries with lower structural vulnerability; HSV: countries with higher structural vulnerability.

3.2.2. *Association between energy poverty and health*

The association between health outcomes and EP_A is shown in Fig. 3 (subfigures a-c). Detailed data can be found in the supplementary information (S3). Once more, there was an overall statistically significant association between EP_A and the selected health indicators. Depression was again the most closely associated health outcome with EP_A and that whose PR values experienced the most oscillation over time.

Between 2007 and 2012, time tendencies were less homogeneous between the groups. The strength of the association between EP_A and health outcomes tended to decrease in men in HSVc and especially in LSVc populations, where the decrease was statistically significant in poor self-reported health status and reduced well-being in women and in depression in men. In women in HSVc, point estimates generally showed a constant increase throughout the study period. The increase in the strength of the association between 2012 and 2016 was observed in all groups, but was particularly marked in women in both LSVc and HSVc and in men in HSVc (generally, p-values of the year interaction<0.05).

3.2.3. *Population impact of energy poverty on health*

The PAR% to EP_A of the three health outcomes is shown in Fig. 3 (subfigures d-f). Detailed data can be found in the supplementary data (S4). Again, EP_A had a significant negative impact on all health indicators, but this impact evolved differently over time according to macro region and sex. Point estimates suggested a general constant increase in the impact of EP_A on health in HSVc. The trends in LSVc were less evident. The impact of EP_A on health in women in LSVc decreased between 2007 and 2012 and tended to increase after 2012. In men, in contrast, the impact of EP_A on health remained stable or decreased throughout the study period.

4. Discussion

4.1. *Principal findings*

The results of this study show that EP clearly increased in the EU during the economic crisis and decreased in more recent years. It also evidences regional and sex inequities in the distribution of EP across the EU, with higher EP prevalence in women and in HSVc. The main contribution of this study is the evidence generated on the effects of EP on health and well-being. We found a significant association between EP and poor self-reported health status, reduced well-being, and depression. Analysis of changes over time showed that the strength of the association between EP_T and health increased from 2007 to 2012. Between 2012 and 2016, the association between EP_T and health tended to decrease in men in LSVc, but not in women in LSVc or men and women in HSVc, where the association remained stable or became stronger. Time tendencies of the association between EP_A and health were less homogenous between 2007 and 2012. But, between 2012 and 2016 there was a general increase in the strength of the association, which was particularly significant in men in HSVc and in women in both LSVc and HSVc. Although the strength of the association between EP and health tended to be greater in LSVc, the impact of EP on the three health outcomes was clearly greater in HSVc. The impact of EP_T on health followed a "peak" pattern over time, increasing between 2007 and 2012 and decreasing between 2012 and 2016. Analysis of the impact of EP_A on health showed a tendency to constantly increase in women and men in

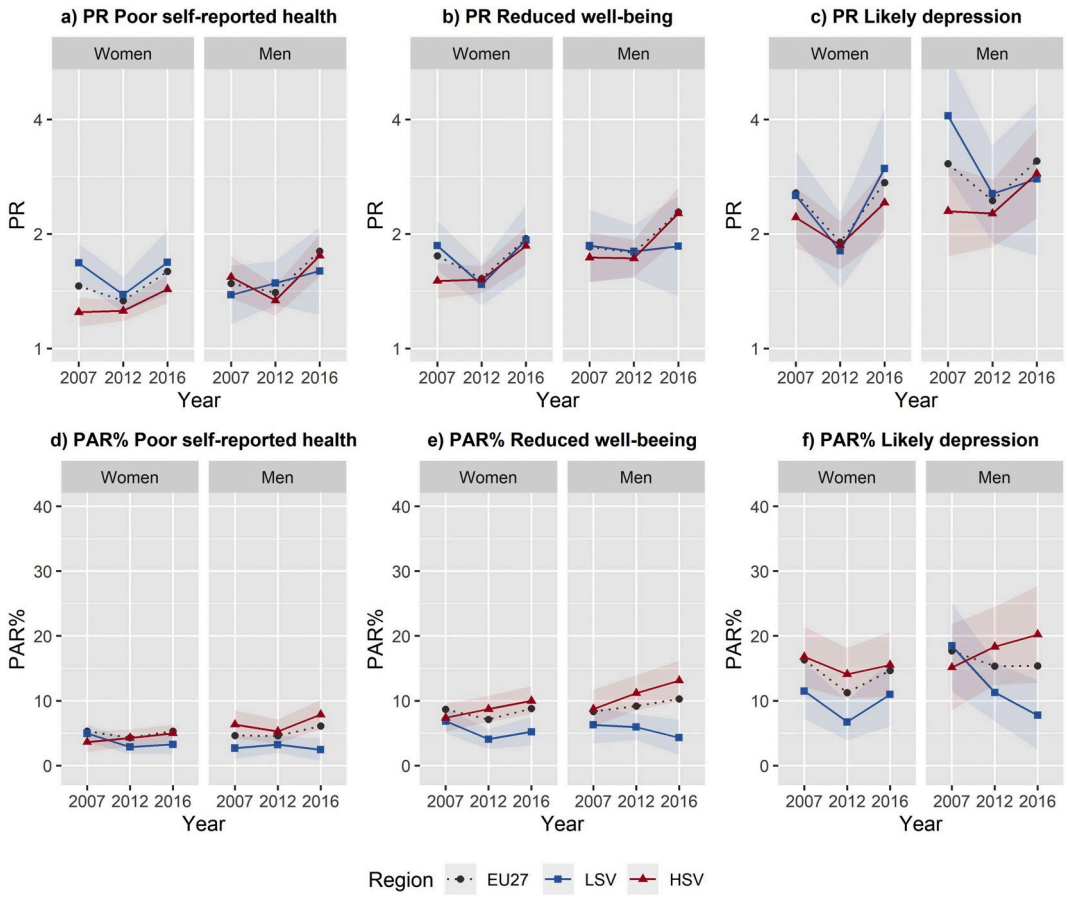

Fig. 3. Age-adjusted prevalence ratio (PR) of poor self-reported health status, reduced well-being and likely depression in people with EP_A versus people without EP_A over time and respective age-adjusted population attributable risk percent (PAR%) of the three health outcomes. Results are stratified by sex and region.
EP_A: energy poverty indicator "One or more arrears in utility bills during the past 12 months"; PR: age-adjusted prevalence ratio; PAR%: age-adjusted population attributable risk percent; LSV: countries with lower structural vulnerability; HSV: countries with higher structural vulnerability.

HSVc. In LSVc, the tendencies were less evident; however, between 2012 and 2016 the impact of EP_A on health tended to decrease in men and to increase in women, particularly regarding depression.

4.2. *Interpretation of results*

To our knowledge, this is the first study analysing the trend in EP at the European level for the period 2007–2016 and including structural vulnerability to EP. The general "peak" pattern observed is consistent with the hypothesis that the structural determinants and the main drivers of EP were directly affected by the economic crisis and subsequent austerity-driven economic policies implemented in the EU, increasing the number of households that were unable to meet their energy needs. These findings support those of single country studies in Spain (Tirado Herrero et al., 2016; Tirado Herrero and Jiménez Meneses, 2016), Greece (Dagoumas and Kitsios, 2014), and England (Hills, 2012). On the one hand, the number of people at risk of poverty or social exclusion increased after the beginning of the crisis, reaching a peak in 2012, and decreased again slightly between 2012 and 2014. On the other hand, in the EU, average electricity prices increased by 29% between 2005 and 2011, a far larger increment than in other regions such as the United States of America, where average electricity prices increased in the same period by 5% (Csiba et al., 2016). Moreover, as argued by Recalde et al., HSVc are characterised by lower expenditure on social protection, higher long-term unemployment rates (and policies to address them based on unemployment benefits rather than activation measures), increased in-work poverty, poor dwelling efficiency and lack of adequate heating systems in the housing stock, as well as by having less active energy markets, among other factors. This baseline or structural situation in HSVc could explain their higher percentage of EP as well as the greater impact of the consequences of economic crises, which together seem to have pushed a substantial number of energy-vulnerable households into EP.

Consistent with other studies, we found a clear association between EP and negative health outcomes. This association was stronger and more susceptible to the effect of the economic crisis in the mental health dimension, particularly in depression. This may be due to the multiple, and sometimes short-term, mechanisms and pathways in which EP affects mental health, which could have an exponential effect (Liddell and Guiney, 2015). Examples include chronic thermal discomfort, which has a direct impact on mental health (Gilbertson et al., 2012), concern that cold is damaging physical health (Tod et al., 2012), worry about energy bills (Anderson et al., 2012), the experience of falling into debt (or fear of it) (Tod et al., 2012), stigma within the person's community (Anderson et al., 2012), and the absence of any solution or sense of control over the problem (Liddell and Guiney, 2015). EP often goes hand with hand with housing insecurity and household financial debt, which are also associated with worse mental health, as well as with worse physical health. Both situations increased during the economic crisis across the EU, and particularly in some of the HSVc, such as Greece, Portugal, Cyprus, and Spain (Vásquez-Vera et al., 2016; Sweet et al., 2013). The economic crisis also increased unemployment rates in many EU countries. Several studies have shown, how unemployment can have negative consequences on mental health, and these can be harder in the case of long-term unemployment and in countries with weak unemployment protection systems and without

active-labour-market programmes, as is the case in HSVc (Karanikolos et al., 2013; Uutela, 2010). Finally, the healthcare sector was also subject to austerity measures which varied from freezes to severe cuts. Some of the HSVc like Greece, followed by Portugal and Italy and Spain to a lesser extent, were the most affected countries (Serapioni, 2017; Simou and Koutsogeorgou, 2014). All this could contribute to the observed association between EP and worse health outcomes and to its trend over time.

Surprisingly, we found that generally the association between EP and negative health outcomes may be stronger in LSVc, particularly when we used the EP_T indicator. These results are in line with the findings of previous research, reporting that Slovenia, Sweden, the Netherlands, Luxembourg, and Denmark experienced the greatest difference in health outcomes among people with and without EP (Thomson et al., 2017a; Healy, 2004). LSVc have higher levels of median income and income equity (Eurostat. Quality of life, 2018) and therefore the absolute deprivation is lower. However, substantial research suggests that this unexpected result could be partly explained by relative deprivation, that is, individual-level socioeconomic comparison (Adjaye-Gbewonyo and Kawachi, 2012). Furthermore, LSVc shape the centre and north of Europe, where cold temperatures during winter are more extreme. This fact could explain why, when people live in EP, the effects on health are likely to be greater and is consistent with our observation that the EP_T indicator was more sensitive to this effect. This should alert us that the traditional focus on cold when studying EP and the lack of studies analysing the effect of hot temperatures in people with EP, could underestimate the already greater impact of EP in Mediterranean EU Member States, which are all included in HSVc. Including the effect of hot temperature when studing EP could increase even further the observed regional inequalities between LSVc and HSVc.

As expected, we observed a general increase in the strength of the association between EP_T and health during the first years of the economic crisis. However, between 2012 and 2016, the trend in the association followed different patterns among groups. On the one hand, men in LSVc tended to recover after 2012, but not women in LSVc or men and women in HSVc, where the association remained stable or became stronger. These findings suggest an increase in health inequalities between regions and genders. Although counterintuitive, the observed decrease in the strength of the association between EP_A and health in women and men in LSVc and men in HSVc during the first years of the crisis has been reported in other studies analysing health trends during the economic crisis (Bartoll et al., 2015; Malmusi et al., 2018). A possible explanation could be that, in times of recession, if more people experience difficulty in paying utility bills, the pool of people living in EP_A tends to include a larger fraction of healthy people, leading to a decrease in aggregated levels of poor health outcomes rather than an increase. This underlying idea is consistent with our finding that the association between EP_A and health became stronger after 2012, when the percentage of people living in EP_A was significantly lower and therefore may represent a more vulnerabilised and affected population. This observed increase was more significant in women in LSVc and women and men in HSVc, supporting the hypotheses that health inequalities may have increased between regions and genders during the economic crisis.

Although the association between EP and negative health outcomes seems to be higher in LSVc, when we analysed the impact of EP, the pattern was reversed, with HSVc clearly being the most affected countries. This is because PAR% is dependent not only on the strength of the association between EP and health, but also on the proportion of individuals exposed to EP, and therefore provides a measure of the public health impact of EP on the entire population. This is essential to assess the potential impact and the cost-effectiveness of preventive interventions at the population level (Rückinger et al., 2009). PAR% are infrequently reported, which may lead to misinterpretation of the real magnitude of the problem and to overlook the existing inequities among different groups. For example, another study analysing the same dataset as ours but just for 2012 concluded that EP produced the largest inequalities in health and well-being in Sweden and Slovenia (Thomson et al., 2017a). Calculating PAR%, we observed that Sweden was one of the EU27 countries with a lesser impact of EP on health and that, among HSVc, Slovenia also showed one of the less significant impacts. In contrast, in 2012, the countries where EP had a greater impact on health were Cyprus and Greece (S14-16), which are both considered as HSVc. It should be noted that impact measures presume causality between risk factors and health outcomes. Cross-sectional studies, as is the case in the present study, do not allow us to prove causal relationship.

The results of this study show how the impact of EP_T on health followed a clear "peak" pattern over time. This "peak" pattern was more pronounced in HSVc, which again suggests an increase in health inequalities among regions during crises. These results are in line with the study by Toffolutti and Suhrcke, who argue that social protection expenditures, which are generally greater in LSVc, appear to help countries to "smooth" the health response to recession (Toffolutti and Suhrcke, 2014). The impact of EP_A on health varied differently over time, depending on region, but also on gender. We observed a constant increase in women and men in HSVc, but different time patterns between the sexes in LSVc, where after 2012 the health impact of EP_A decreased in men and increased in women, as in women and men in HSVc. Intersectionality may be a valuable analytical tool to understand the ways in which both axes of inequality, territory and gender, intersect with each other, resulting in specific realities that may affect health in different ways. Several reports suggest that women are more affected by EP than men due to economic, biological/physiological, and socio-cultural factors (Clancy et al., 2017). Women with low incomes are disproportionately found as heads of households either as single parent families or due to their greater longevity than men, living alone at pensionable age. In addition, EP could have a greater impact on women's health because they are considered more sensitive to ambient temperature and because women still bear the burden of care and housework, tasks that are energy intensive and imply spending more time at home (Gonzalez Pijuan, 2018; Brodolini, 2011). Women are also responsible for energy management in the household. This puts them in conflict with other family members (a situation that is exacerbated in times of austerity) and makes them responsible for dealing with unpayable debts or requesting subsidies. These situations, which are strongly related to stress, feelings of helplessness, depression and stigma, have been reported in studies in both LSVc (Roehr, 2002; Carlsson-Kanyama and Lindén, 2007) and HSVc (Gonzalez Pijuan, 2018; Petrova, 2017).

4.3. Methodological considerations, strengths and limitations

EP is a complex phenomenon whose measurement provokes broad debate. In this study we used the consensual approach and addressed the affordability dimension of EP. The lack of information on other dimensions of EP such as access, flexibility, energy efficiency, needs, or practices, may hamper understanding of the various causes underlying EP and its effects on health. Because the indicators used in this study are dichotomous, we could not capture intermittent versus persistent thermal discomfort or arrears in utility bills. This approach does not allow measurement of the intensity of EP in households, which could confound the association between EP and health. However, the use of subjective indicators is believed to incorporate a more comprehensive perspective of EP and to be less complex to collect, allowing their use at the European level (Thomson et al., 2017b). Moreover, we analysed the two indicators separately because they do not measure the same issue and, therefore, the mechanisms and pathways mediating their association with health may differ. Further studies should also overcome the dominant focus in EP research on heating and examine other energy needs in greater depth such as cooling, lighting, and the use of modern appliances such as computers or phones.

EP is considered a distinct deprivation condition and not only a symptom of a broader problem of poverty (EPEE, 2009; Bollino and

Botti, 2017; Hills, 2012). Although there is a clear overlap and linkages between income poverty and EP, EP should be considered separately because 1) not everyone who is energy poor is income poor, 2) some of the negative health outcomes of EP are more immediate than those caused by income poverty and 3) EP is more amenable to change than income poverty, since factors other than income can be tackled to reduce EP (Marmot Review Team, 2011). One example is Barcelona's Energy Advice Points (EAP), a service to guarantee the rights to energy and basic supplies, as well as to improve the energy efficiency of homes in the city of Barcelona. The EAPs offer personalized services such as guidance on improving the management and energy efficiency of households or the support and processing of grants, fines or procedures with companies to optimize bills (change of power, rate or company, elimination of unnecessary additional services, etc.) (Ecoserveis, 2011; Memoria d'actuació. Punts, 2018). Another example is the Warm Front scheme in England, a programme to improve energy efficiency of private households in or at risk of EP, which showed positive impacts on alleviating EP and therefore improving mental health, alleviating respiratory problems in children and reducing deaths of older people (Gilbertson and Green, 2008). However, EP disproportionately affects low-income households. To ensure that low income is not the only EP driver that explains the association found between EP and negative health outcomes, we conducted a sensitivity analysis and repeated all analyses for the lowest income quartile. We decided to stratify rather than adjust the analyses by income because income is one of the underlying causes of EP and from a conceptual perspective, we do not consider it appropriate to soften the health effects of EP through income adjustment. This extra analysis for the lowest income quartile confirmed that the low-income population experiences more EP than the general population. Regarding time trends, EP followed the same "peak" pattern in LSVc as in the general population, but this was not the case in HSVc, in which EP affecting a high proportion of women tended to remain stable and increased in men to women's levels. Strikingly, the association between EP and the three health outcomes remained statistically significant in this subpopulation. This extra analysis therefore reaffirms that removing the effect of low income does not remove the clear association between EP and negative health outcomes. We would have liked to conduct a more in-depth examination of how socioeconomic factors modulate the relationship between EP and health but were unable to do so because the income variable showed 25.2% missing values, which would have invalidated the results. For this reason, the results for the lowest income quartile should also be interpreted with caution and are therefore not published in this paper.

In an increasingly globalised and consumer-oriented world, health issues and their determinants increasingly require a transnational perspective (Kickbusch, 2010; Kickbusch et al., 2016). Rethinking boundaries when studying public health issues helps to elucidate the underlying global relations of social determinants of health. A strength of this study is that we analysed the relationship between EP and health across two macro regions, which share key characteristics among the structural determinants of EP. This has enabled us to obtain a broader perspective of the relationship between EP and health and of its susceptibility to external factors such as the economic crisis. At the same time, the economic crisis did not affect all EU countries equally and we are aware that every country has its particularities, which could be overlooked by aggregating data. Single-country data is also essential to advocate actions at the country level. For all these reasons, the whole analyses by country can be found in the supplementary information (S5–S19). Due to the sample size, we could not stratify the analyses by sex. Given the observed sex inequalities, in-depth research using the gender perspective is needed at the country level.

5. Conclusions and recommendations

This study clearly recognises EP as an important public health problem across the EU. We found a strong association between EP and poor health, especially poor mental health, which, combined with a high prevalence of EP, translates into a high impact at the population level. The results show that EP and its impact on health tend to worsen during the economic crisis and identifies vulnerable groups such as women and people living in HSVc. Further research should investigate the increasing regional and gender inequities in the distribution of EP and its impact on health. EP is a complex phenomenon and its solution requires tackling its structural determinants. It is essential to put people and their health and well-being at the centre and rather than conceptualizing energy and housing, among others, as market goods, recognizing them instead as rights. Health must be mainstreamed into all policies at European, national and local level.

Contributors

LO and MM contributed in the conception and design of the study. All the authors contributed to the acquisition and interpretation of data. LO and MM performed the statistical analyses. All the authors contributed in the interpretation and the discussion of the results. LO wrote the first draft of the paper. All the authors critically revised the manuscript and approved the final version. The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Ethics approval

This study has been approved by the Clinical Research Ethics Committee of Hospital del Mar (2015/6155/I).

Transparency declaration

The lead authors (LO and MM) affirm that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Data sharing

Dataset is available free of charge to those who intend to use it for non-commercial purposes at the UK Data Service.

Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.healthplace.2020.102294.

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