Learning from the Past

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Learning from the Past: The Impacts of Economic Crises on Energy Poverty Mortality and Rural Vulnerability

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Abstract: The summer-dominated Mediterranean island of Cyprus is often considered in the contexts of beach tourism, sunny weather, and different types of business economic activities and services. In terms of its climatic conditions, extreme heat and mild winters characterise the island; yet, recent evidence has shown that winter poses a significant threat to public health. Its excess winter mortality is amongst the highest in Europe and there is an increased risk of energy-poverty-related mortality compared to total mortality. This study is an extension of previous research, with the objective of further scrutinizing the shift observed between urban and rural energy poverty mortality in the time of a severe nationwide financial crisis. Mortality and temperature data for the period of 2008–2018, as well as macroeconomic indicators, were investigated through a linear regression analysis. The results indicated that the declining economic situation of the island severely hit rural areas, with a significant increase in energy-poverty-related mortality, while urban areas were more resilient to this. There are three existing challenges linked to energy poverty: low incomes, high energy prices, and poor building energy efficiency. In Cyprus, all three coincide and are aggravated in times of crisis, creating conditions of extreme vulnerability for populations already in a disadvantaged position. This study's motivation was to highlight the intense vulnerability associated with crises in Cyprus, and its outcomes call for higher levels of support at such times, especially when it comes to rural populations.

Keywords: energy poverty; mortality; outdoor temperature; financial crisis; GDP; urban and rural vulnerability

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1. Introduction

During the past few years, European countries have experienced several large-scale challenges related to the energy systems they rely on, including rising demand, price hikes, and endangered supply chains. Cyprus is the third-smallest country in the European Union (EU) and one of the biggest islands in the Mediterranean Sea, being the only member state still isolated from all EU energy networks. There have been ongoing efforts to end the island's energy isolation, with the latest news announcing the initiation of the construction of interconnecting electricity cables between Cyprus and Crete, acquiring funding and political opinions on the topic [1,2]. Nevertheless, the population of Cyprus still presently (and for the near future at least) relies mostly on fossil-fuel-generated electricity. Cypriot citizens are now faced with another price spike, resulting from a perfect storm of penalties imposed on consumers' utility bills for missing the national greenhouse emission targets [3], the Russian–Ukrainian conflict, and a possible upcoming financial crash [4]. Combined with the abridged electricity prices in periodic intervals shortly after the COVID-19 pandemic, the price of electricity for household users increased by 43% between the second term of 2020 and first term of 2022 [5]. Such large fluctuations are not uncommon in the contemporary history of this country (Figure 1), with the price of electricity in Cyprus following the trend of crude oil prices more closely than the cost of electricity in the rest of the EU [6]. The oscillating energy prices in Cyprus are owed to the energy isolation encountered by the island and its pure reliance on heavy fuel oil for electricity generation, rendering households and businesses vulnerable to any and all external shocks of the economy.

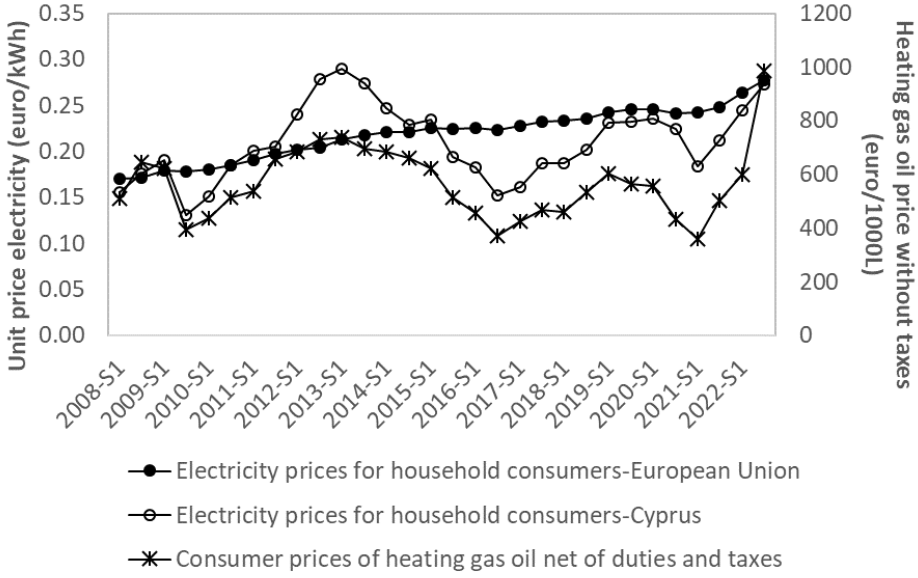

Figure 1. Price of electricity in the EU and Cyprus and average price of heating gas oil, first half of 2007–first half of 2022. Sources: Eurostat [5] and DG Energy [7].

One of the areas where crises severely impact societies' most vulnerable groups is energy poverty, which is defined as the inability to attain socially and materially necessitated energy services in the home [8,9]. The price of energy is one of the main drivers of energy poverty and the oscillating price of electricity in Cyprus poses a significant threat to the most vulnerable portions of its population. According to the latest official reporting, approximately 3% of the population is energy poor in Cyprus [10]; however, the calculation method for this has been criticised for its unreliability and inaccurate representation [11]. Moreover, economists have assessed a steep increase in the number of people affected by energy poverty due to poorly designed and built houses and as a result of the hiking of energy prices and economic instability [12]. Low income is, therefore, another determinant of energy poverty, as well as the poor energy performance of dwellings. Foremostly, a precarious economic situation, the diversity of its socio-economic activities, and the lack of legislation for minimum wage have resulted in substantial income inequality in Cyprus [13]. This is especially pronounced in times of large-scale disruptions; for example, the Gini index showed a marked increase starting in 2011 and peaking in 2013 (from 31.5% to 37%) [14], at a time when the country was going through a major banking crisis, which was initiated by the collapse of the Lehman Brothers Bank in the USA [15]. To counteract such inequalities, the national government adopted a minimum wage in January 2023 [16]. In terms of building performance, the Renovation Wave of the EU is expected to improve the current situation, which nevertheless remains highly problematic.

Most buildings in Cyprus were constructed between 1980 and prior to 2006, during a period characterised by a lack of regulations for minimum energy efficiency requirements; indeed, the first minimum energy performance criteria were introduced in 2007 [17]. Furthermore, the Cyprus building stock is quite aged and would require a substantial renovation, which is proceeding at an extremely low rate [18]. Moreover, an Energy Performance Certificate (EPC) was not obligatory for new or significantly renovated buildings until 2009 [18], resulting in the majority of residential buildings remaining in poor, yet uncharacterised conditions, with only 10% of existing buildings being issued an EPC [19]. Although the role of indoor conditions has been unequivocally linked to situations of energy poverty, it has only recently been taken into consideration in the legislative framework of Cyprus. Unlike many EU countries, Cyprus has included a definition for energy poverty since 2013, embedded in the Law for the regulation of the electricity market [20]. Albeit flawed, this definition has been reviewed several times, with the most recent one occurring in 2021, mentioning that the energy efficiency of dwellings should be considered when defining vulnerable consumer groups in energy poverty situations [21].

2. State of the Art

The legal recognition of energy poverty and the role that housing plays in perpetuating this condition is essential, given the significant associations between the conditions typically related to energy poverty—such as excessively low or high indoor temperatures, the presence of mould and dampness, and adverse physical and mental health. The Marmot Review, one of the most widely cited reports on the Health Impacts of Cold Homes and Fuel Poverty [22], found a strong relationship between cold temperatures and cardiovascular and respiratory diseases, reconstructing links between cold housing and minor illnesses such as colds and flu. Beyond the physical consequences of inadequate housing on human wellbeing, in the literature, poor mental health has also been associated with conditions of energy poverty, implicating social isolation and anxiety in poor living conditions, debt management, and inadequate temperature conditions [22–28]. For decades, specific population groups have been described as being most vulnerable to the effects of low temperatures, including the elderly, children, and people with disabilities and existing physical or mental health conditions [29–31]. The recent literature has taken on a gendered approach as well, identifying the increased risks and challenges that women face [32]. For instance, Sánchez-Guevara Sánchez et al. [33] explored the feminisation of energy poverty in a Mediterranean city and described the gender gap.

The literature related to energy poverty and public health has also examined the topic of Excess Winter Deaths (EWD) in detail, with indications that chronic and severe impediments are linked to EWD, while specific groups such as the elderly are more susceptible to winter mortality [34–36]. Physical health—respiratory and cardiovascular conditions in particular—has been associated with cold homes and an associated higher risk of morbidity and mortality [37]. Poor indoor thermal conditions, however, also pose a significant threat to human wellbeing and mental health [38,39]. Excess winter deaths and their associated conditions, aggravated by energy poverty, have also been examined through the lens of climate change, with conflicting evidence on the role of the warming climate in EWD incidence [40–42].

As for the energy performance of buildings, highly energy-efficient housing conditions have been linked to lower EWD rates, while southern European countries with warmer climates, such as Cyprus and Malta, are showing a higher excess mortality in non-summer months relative to the colder EU member states [43–45]. In southern Europe, the quality of the building stock and lifestyle adjustments have been suggested as the main drivers of this augmented EWD rate [46]. Despite its extended application, the EWD methodology has been criticised and researchers have turned to alternative versions of this indicator, which better describes the cold months of many EU countries [46,47]. For instance, a project report on the multiple benefits of energy efficiency in Europe (COMBI project) estimated the excess cold mortality for the period of 1996–2014 and concluded that, annually, an average of approximately 70,000 premature deaths took place due to indoor cold exposure. Translated into economic terms, this was estimated to be analogous to a societal loss of EUR 6.7 billion [48].

A previous study of the authors showed that, in Cyprus, outdoor ambient temperature is significantly linked to mortality owing to respiratory and cardiovascular causes of death. Furthermore, a 20-fold higher risk of death in winter and a major shift in mortality around 2013 were observed from an elaboration of the national statistics and data gathered from the Ministry of Health. This mortality shift occurred during a severe national financial crisis, which primarily hit rural populations exposed to a substantially higher mortality risk caused by conditions related to energy poverty [44]. Despite the rich literature on energy poverty research, a gap can be detected in relation to the link among altered energy vulnerabilities in times of crises and the impacts this has on public health, a topic detected by our previous analysis.

The present study therefore builds upon our past work to further examine the mortality related to energy poverty issues during a recession, using macroeconomic indicators and statistical analyses. The ultimate objective of the investigation was to reinforce the urgency for action in the midst of the multiple crises occurring simultaneously in Cyprus. By providing evidence-based research and pinpointing the most vulnerable populations, specific recommendations can be extracted to strengthen the existing support with a long-term horizon. The novelty of this work lies in the cross-examination of macroeconomic conditions and public health in a spatial domain, between urban and rural areas, on a temporal scale that includes a major shock to Cypriot society. This study may provide insights for projecting the impacts on vulnerable groups in the dark shadows of the recent pandemic and energy crises spanning from 2020 to current times. In addition, near-future threats are detectable, with the banking instability that started in early 2023 in the USA already projected to have multiple ripple effects [49,50] and propagating, for the time being, to a few countries on the European continent [51–53].

3. Materials and Methods

The temperature and mortality datasets and data pre-processing are identical to the previous work of the authors [44]. The novelty of this study is the integration of macroeconomic indicators and a higher-level statistical approach to determine the significance in mortality shifts among correlations of different periods (before and after the economic shutdown). The sections below elaborate on the selection of temperature as a link to energy-poverty-related mortality, the temperature and mortality datasets and statistical methods adopted, and the macroeconomic and EU-SILC data utilized.

3.1. Selection of Temperature as a Link to Energy Poverty-Related Mortality

In human physiology, thermoregulation is essential for the maintenance of bodily functions and good health. Exposure to overwhelming cold or heat can lead to temperature stress and, eventually, hypothermia and heatstroke or hyperthermia. If the human body cannot maintain its core temperature at approximately 37 °C, other indirect issues, such as respiratory and cardiovascular conditions, are likely to arise [54]. In cold stress, the core temperature falls below 35 °C and a systemic response is triggered, where the muscles contract and shivering occurs, while heart and breathing rates increase in efforts to generate heat [37]. The elderly and neonates are at a higher risk of hypothermic morbidity and mortality, as they have a decreased capacity for shivering and vasoconstriction [54]. Hyperthermia caused passively (i.e., not actively caused through exertion) occurs when the body temperature exceeds 40 °C, and the body's response is to release heat, mainly through sweating. Additionally, in this case, children and the elderly are more vulnerable due to their more limited thermoregulatory capacity [54]. While both conditions impose significant health impairments, hypothermia is estimated to be responsible, on average, for twice the number of deaths relative to hyperthermia. Moreover, passive heat strokes are more likely to occur during extreme heat events, while passive cold-related morbidity is related to the absence of adequate warm clothing or shelter, irrespective of the intensity of cold weather [54].

It is likely that, because of the higher occurrence of cold-related morbidity and mortality, more attention has been focused on deaths occurring during the winter season, resulting in epidemiological indicators such as the EWD being developed and scrutinised over the past decades [36,43,46]. While the energy poverty literature has previously often related low temperatures to mortality and inadequate housing [34,45,48,55], in recent years, heat-related health risks have also been investigated [56–58]. Nevertheless, neither heatstroke nor hypothermia can be listed as official causes of death; instead, respiratory and cardiovascular diseases are most likely to be cited, coded based on the International Classification of Diseases currently in use (ICD-10). For this reason, this work coins the term "EP mortality" to describe a higher likelihood of any one of a range of aspects related to energy poverty affecting mortality, without exclusively attributing the accounted deaths to energy poverty. The specific ICD-10 codes selected were: I05–I09, I10–I15, I20–I25, I26–I28, I30–I52, J00–J06, J09–J18, J20–J22, J30–J39, J40–J47, J60–J70, J80–J84, J85–J86, J90–J94, and J95–J99.

3.2. Temperature and Mortality Datasets and Data Processing

In light of the temporal shift in vulnerability observed in the previous work [44] and in order to test for significant changes in mortality following the 2013 national economic crisis, a further analysis is conducted to examine the link between the minimum monthly temperature and mortality pre- and post-2013. The data were collected and pre-processed as described in Kyprianou et al. (2022), representing the areas controlled by the Republic of Cyprus [44]. Longitudinal mortality data and temperature records from 36 weather stations for 2008–2010 and 50 stations for 2011–2018 were used to study the effects of temperature on mortality between 2008 and 2018 (11 consecutive years). Given the small geographical scale of Cyprus (less than 6000 km^2 and about 1 million in population), both datasets were rearranged to represent the urban and rural areas of the island in order to provide a satisfactory spatial distinction, as well as an adequate statistical significance. Both datasets were tested for normality and found to be non-normal; therefore, parametric statistical tests were used throughout the study (Spearman's Rank Correlation to study the effects between two variables and the Mann–Whitney U Test to study the effects between two correlations). Moreover, for the spatial analysis between the urban and rural regions, the data were normalised using the corresponding population densities. For this analysis, the temperature dataset refers to the minimum monthly temperature, because it has been shown to be the temperature parameter with the highest correlation coefficient [11]. In order to test whether any of the correlations were more significant than others, a modified version of the Fishers Z transformation was used. This type of analysis is common for assessing the differences between two correlations, and with some modifications, it can also be applied to Spearman's rho [59]. Using SPSS Syntax, the Z-values were calculated to test the null hypothesis, showing that no statistical significance exists between the two correlations. If the Z-value was between -1.96 and 1.96, the null hypothesis could not be rejected. If the Z value was larger than 1.96 or smaller than -1.96, the null hypothesis was rejected at the 0.05 significance level.

3.3. Macroeconomic and EU-SILC Data

Due to its transient and dynamic nature, energy poverty is a phenomenon hard to define with a general consensus. Moreover, due to the lack of a universally agreed definition, a variety of indicators and composite indices have been developed to detect energy poverty; these have been thoroughly examined and critiqued [60–66]. Novel methodologies and perspectives on energy poverty have been introduced, including the impacts of climate change on the future electricity demand and its related energy vulnerabilities, indoor air pollution as a consequence of non-modern heating fuel use, and interactive tools showing responses towards the relief of energy poverty during the pandemic [67–69].

In this study, economic indicators available on an open-source basis were used to assess different aspects of mortality during a critical economic period. These included the gross domestic product (GDP) per capita obtained from WorldBank [70], the percentage of rural and urban populations in Cyprus unable to keep their homes adequately warm downloaded from EPAH [71], and the persons at risk of poverty or social exclusion by the degree of urbanisation and the percentage difference between urban and rural areas from Eurostat [72]. After the data collection, pre-processing for data curation, normalisation, and standardisation were performed, and given the nature of the problem and type of variables, a linear regression analysis was employed to investigate the relationship between macroeconomic indicators and mortality in Cyprus.

4. Results

Building on previous research [44], this study examined the potential of physical and economic conditions to affect energy-poverty-exacerbated mortality (EP mortality). The entire study period covered the 11 years between 2008 and 2018, and, in this research, this was split into two distinct terms to reflect the conditions before and after the 2013 crisis: January 2008–December 2013 (Period A) and January 2014–December 2018 (Period B). The year 2013 was included in Period A because the crisis was a direct consequence of the economic conditions happening worldwide after the American banking crisis of 2008. A study of two separate sub-periods was selected here to examine possible ripple effects of this major banking crisis and its impacts on the socio-economic conditions of the population.

Linear regression on the two time periods for the Total and EP mortality showed that the coefficients were positive and indicative of mild-to-strong correlations [73]. The regression coefficient of the EP mortality to the minimum ambient temperature was always stronger than that of the Total mortality to the minimum ambient temperature, indicating stronger effects of temperature on EP mortality cases.

Further non-parametric statistical tests were carried out on the two separate periods (due to the datasets being found to be non-normally distributed, as described in [44]), before and after the crisis, to examine the correlations between the minimum monthly temperature (MMT) and the Total or EP mortality (Table 1). All of the correlations were significant at the 0.01 level, and the EP mortality always had a higher Spearman's rho than the Total mortality.

Table 1. Spearman's rank correlation for Total and EP mortality against minimum monthly temperature, for two time periods: 2008–2013 (A) and 2014–2018 (B).

	Period A			Period B		
	Total Mortality	**EP Mortality**	**No. of Months**	**Total Mortality**	**EP Mortality**	**No. of Months**
MMT	−0.633 *	−0.717 *	72	−0.776 *	−0.853 *	60

* Correlation is significant at the 0.01 level (2-tailed).

Fisher's Z transformation was adapted to examine whether any one correlation was more significant than others. In this case, four combinations of rho values were tested, indicating the correlation of the minimum monthly temperature with either the Total or EP mortality, for both Periods A or B (Table 2).

Table 2. Z transformation parameters: R1 and R2 are Spearman's rho values; N1 and N2 are the number of months (see Table 1). *Z*1 and *Z*2 are transformed rho values; *Z*-test is computed with *Z*1 and *Z*2 to test the difference between correlations [59].

Combinations with MMT	R1	R2	N1	N2	Z1	Z2	Z-Test
EP mortality A/Total mortality A	−0.72	−0.63	72	72	−0.090	−0.75	−0.89
EP mortality B/Total mortality B	−0.85	−0.78	60	60	−1.27	−1.04	−1.20
EP mortality A/EP mortality B	−0.72	−0.85	72	60	−0.90	−1.27	1.98 *
Total Mortality A/Total Mortality B	−0.63	−0.78	72	60	−0.75	−1.04	1.57

* Z-value outside of critical values.

Three of the combinations had insignificant differences; however, on one occasion, the critical value of Z fell outside of the acceptable range ($-1.96 < Z < 1.96$), indicating that the null hypothesis could be rejected. This test indicated that the correlation of EP mortality with the minimum monthly ambient temperature before the crisis of 2013 was significantly different from the same correlation after 2013. Consequently, it is suggested that the financial shock of 2013 severely affected the relationship between ambient temperature and mortality related to EP causes.

To further explore these apparent effects of the economic crisis on mortality, a financial indicator for Cyprus (GDP per capita) was plotted against the annual normalized mortality (relative to the corresponding annual population) in Figure 2. This chart showed that the GDP declined over the past decade and the Total and EP mortality increased. Although a steady increase in the GDP was noticed between 2015 and 2018, indicating economic recovery, an analogous decrease was not observed in the mortality trends. The lowest GDP per capita was recorded in 2015, in the year that the annual EP mortality reached an all-time high, which was possibly affected by a time lag.

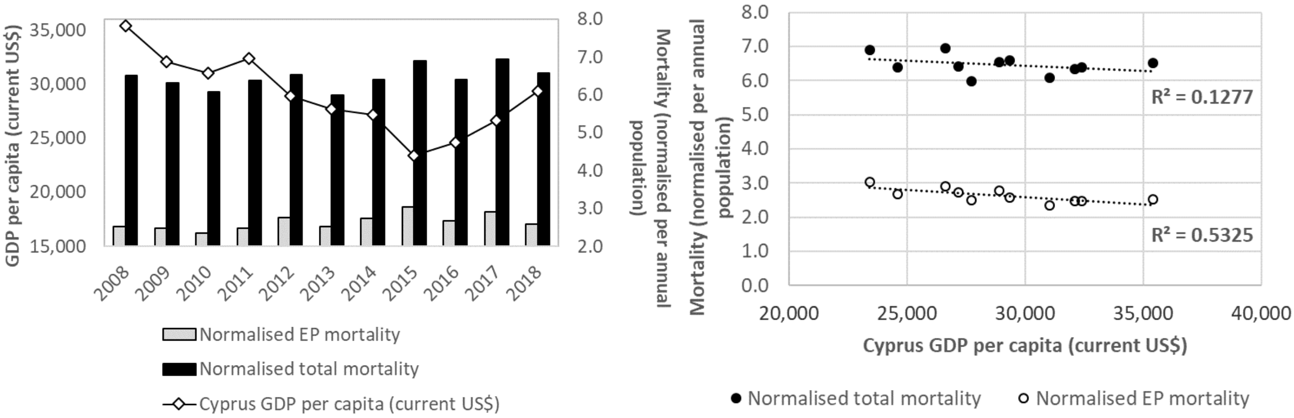

Figure 2. GDP per capita and normalized mortality in Cyprus, 2008–2018 (**left**) and linear regression analysis between normalized EP/Total mortality and GDP per capita (**right**). Sources: own data and WorldBank [70].

Moreover, a linear regression analysis was performed in Figure 2 to test for the statistical significance between the mortality and per capita GDP. No significant relationship existed between the normalised Total mortality and per capita GDP ($R^2 = 0.13$, $p = 0.28$), but a significant negative relationship was detected between the normalised EP mortality and per capita GDP ($R^2 = 0.53$, $p = 0.01$). These results indicated that the declining economic indicators, owing to large-scale financial events in Cyprus, possibly significantly affected the EP mortality but not the overall mortality rate. As indicated by previous health economics research, the absence of a correlation between the GDP and total mortality may be explained as a consequence of a lower exposure to accidental (or other all-cause) deaths, resulting from lower levels of activity, traffic, or work-related incidences [74,75].

Considering the fact that rural regions appeared to have been afflicted more severely than urban areas by the deteriorating conditions of the economy, a further disaggregated regression analysis was performed. This examined the normalised EP mortality (NEP; counts of mortality records divided for the respective populations) for urban and rural areas in relation to the GDP per capita (Figure 3). The urban NEP mortality fluctuated but did not show an increasing pattern, whereas the rural NEP mortality exhibited an increasing pattern throughout the 11-year period. Moreover, while the NEP in urban areas was approximately 14% higher than that in rural areas in 2008, this was reversed and the rural NEP was up to 16% higher than the urban NEP by 2015.

The linear regression analysis on the urban and rural NEP mortality supported these initial findings (Figure 3), indicating that no significant relationship existed between the normalised urban EP mortality and GDP per capita ($R^2 = 0.23$, $p = 0.14$), but a significant and strong negative relationship was detected between the normalised rural EP mortality and GDP per capita ($R^2 = 0.76$, $p = 0.00$). This analysis showed that the declining economic situation of the island had a significant impact on the rural NEP mortality alone.

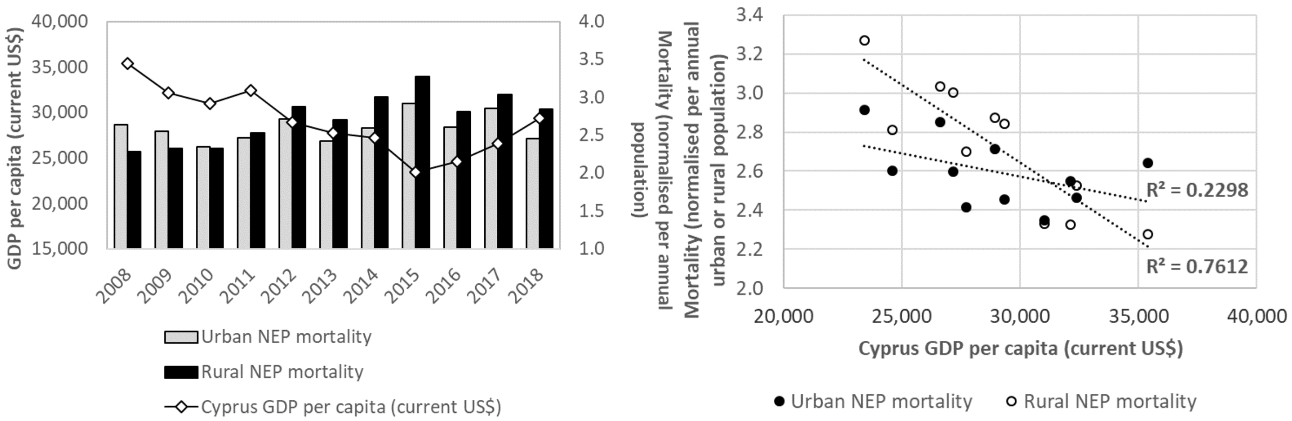

Figure 3. GDP per capita and normalized EP mortality in Cyprus, 2008–2018 (**left**) and linear regression analysis between normalized urban EP/rural EP mortality and GDP per capita (**right**). Sources: own data and WorldBank [70].

According to key macroeconomic indicators, populations of thinly populated and rural areas of Cyprus are dealing with more severe hardships than those living in cities. For instance, thinly populated areas consistently have more difficulties in the ability to keep their homes adequately warm compared to populations living in dense urban centres, and are at a greater risk for monetary difficulties and deprivation (see Figure 4).

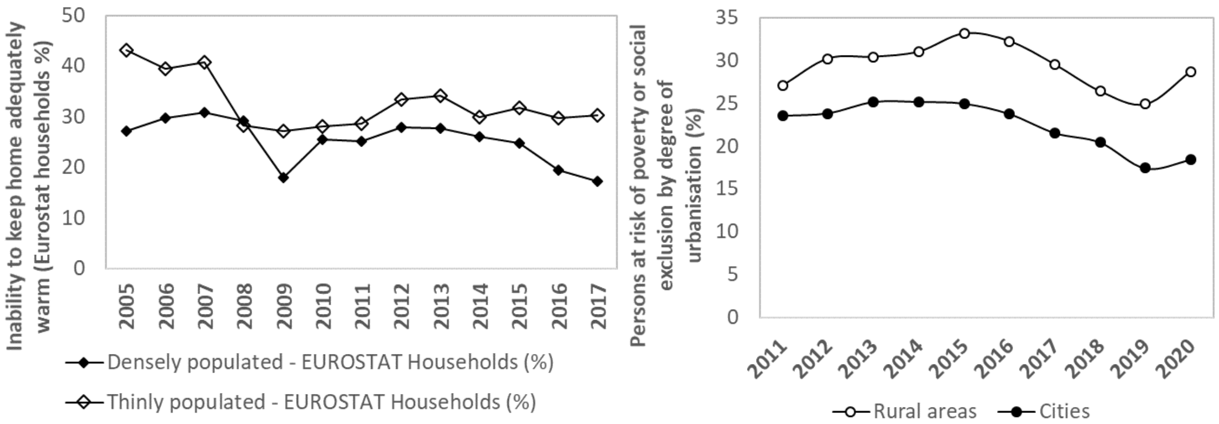

Figure 4. Percentage of rural and urban populations in Cyprus unable to keep home adequately warm, 2005–2017 (**left**) and persons at risk of poverty or social exclusion by degree of urbanisation, 2011–2020 (**right**). Sources: EPAH [71], Eurostat [72].

Rural areas are also more vulnerable to fluxes of the economy and becoming increasingly disadvantaged in times of crisis. For instance, while a similar trend for the risks of poverty or social exclusion was observed in cities and rural areas over 2011–2020, there was higher variation in rural populations, which was most noticeable after the 2013 banking crisis and at the end of the study period, when the consequences of the pandemic were reflected in the EU survey (Figure 4).

Moreover, research findings have shown that countries with mild climates, low or average macroeconomic indicators (such as GDP), and high energy prices are linked to high levels of energy poverty [76]. Therefore, a general consensus exists among the widely used indicators, as well as the findings reported, implicating proxies of energy poverty, including public health and deprivation, in local socio-economic circumstances.

5. Discussion and Policy Implications

Previous work has shown that peak mortality occurs in the winter season and that populations in Cyprus are 20 times more likely to die during winter relative to the rest of the year, phenomena that are possibly linked to low indoor temperatures and the poor state of the national building stock. Moreover, the shift in rural normalized mortality points towards the increased vulnerability of rural regions and is possibly as a result of a national economic crisis. The statistical evidence presented here shows that, of all the tested relationships, only the relationship between EP mortality and the minimum monthly ambient temperature changed significantly after 2013. Moreover, the normalised energy poverty mortality in urban areas was approximately 14% higher than that in rural areas in 2008, something that was reversed shortly after, with the rural normalised energy poverty mortality reaching up to 16% higher than the urban estimation by 2015. The regression analysis showed that a significant and strong negative relationship exists between macroeconomic indicators and rural mortality related to energy poverty, something that was not observed for the urban normalised energy poverty mortality.

There are two major findings presented in this study, adding new insights to our previous work. The first is that the financial shock of 2013 severely affected the relationship between ambient temperature and the mortality related to EP causes, in relation to the mortality owing to all causes of death. The second is that populations living in remote areas were affected by respiratory and cardiovascular mortality far more severely than all the other tested groups. These observations are supported by EU-wide statistics, showing that rural and thinly populated areas have been exposed to higher vulnerabilities related to energy poverty and material deprivation. Variations in macroeconomic indicators such as GDP affect urban and rural populations in a similar manner. However, it seems that economic instability has a higher impact on rural areas, where variations in GDP amplify vulnerabilities in relation to urban populations.

In early 2013, a major economic disruption occurred in Cyprus as a result of prolonged global economic disorder. This shutdown became associated with a loss of wealth for a large share of the population and crippled the economy. This study does not offer evidence to support a causative relationship among economic circumstances, energy poverty, temperature, and mortality. Nevertheless, the statistical and epidemiological findings presented here show that rural populations may be disproportionately affected by large-scale disturbances and socio-economic turmoil. These findings certainly warrant further research into the effects of extreme events on energy vulnerability and public health in Cyprus, and by extension, countries of this region with similar situations.

In terms of policy implications, the anticipated update on vulnerable consumer groups will better align the beneficiaries of energy poverty measures to match vulnerable populations that also live in poor housing conditions. This is expected to increase the efficiency of the current support measures; nevertheless, the fact remains that the energy consumption in households is still an untouched subject in the legislative framework. Policy reform could possibly be more effective, detaching energy vulnerability from the generic state welfare framework and framing it instead in a more holistic scheme that limits consumption for energy-vulnerable populations. This would have to be carefully considered, since limitations would have to ensure that energy-poor populations would be supported, while the state is protected from exploitation. Moreover, the findings presented here call for extensive support for the rural areas of Cyprus, starting from access to healthcare services and establishing a legal framework for supporting energy communities. As it stands now, it is impossible to create decentralized, renewable energy systems, something that stands as a barrier to delivering clean, affordable energy to remote populations. Considering the energy isolation of the island and the monopoly of the energy supply, consumers are left without options. Alternative fuels such as wood are being favoured in remote areas, both for warmth and as part of tradition, and the stalemate in energy supply options only deepens such habits and makes it harder for populations to turn to clean sources of energy. A possible implication of this could be poor indoor air quality if combustion is not filtered and adequately controlled, something that may be associated with an increase in morbidity and/or mortality due to respiratory conditions.

6. Conclusions

This study serves as a starting point for further research into the effects of socioeconomic and poor housing conditions on public health in Cyprus, and its limitations should be properly identified and mitigated in consequent work. These include assumptions linking high-level, non-longitudinal data on temperature, mortality, and socioeconomic statuses. Moreover, EU and national data on Cyprus are very limited due to the small scale of the island and the low statistical significance when a higher data resolution is achieved. For instance, a postcode may be associated with a single record of mortality on a specific day of the month, therefore endangering personal information and compliance with privacy standards. For this reason, the mortality data needed to be aggregated to a lower level of resolution, both on the temporal and spatial planes, which extended to the temperature and macroeconomic datasets as well. In future work, these limitations could be improved through pilot long-term studies involving real households, both in vulnerable and self-sufficient positions.

The outcomes of this study indicate that the public health issues observed in winter, in one way or another related to energy poverty, can be experienced more severely in rural areas relative to urban contexts. The statistical evidence shows that the rural mortality related to energy poverty conditions was significantly impacted by the economic shutdown experienced by Cyprus in 2013, relative to urban populations. Remote and thinly populated areas also endure harsher weather conditions and more financial hardships, often with limited access to services, especially regarding health. This work may be viewed as a guide and incipience of a new field of research in Cyprus, warranting more robust assessments of climate, housing, and socioeconomic conditions and how they impact human health and welfare.

There are three drivers of structural energy poverty: low incomes, high energy prices, and the poor energy efficiency of buildings. In Cyprus, all three of these drivers coincide and are aggravated in times of crisis, creating conditions of extreme vulnerability for populations already in a disadvantaged position. The dependence of electricity generation on fossil fuel and the energy isolation of the island allow for volatile shifts in oil prices to be transferred onto consumers, who are already taxed with penalties due to missed greenhouse gas emissions targets. Now more than ever, the European Union is calling for pragmatic changes in the existing building stock and policies should reflect the urgency of this, transposing non-technical resolutions to technical solutions. At the same time, national and regional authorities should promote a concept of "living well" in rural and remote areas, as complementary to the current practices promoting cultural heritage and transient visitor populations.

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