ASSESSMENT OF HEATWAVE IMPACTS ON ENERGY POVERTY. INSIGHTS FROM THE FRENCH CONTEXT

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Overview

The early 21st century in Europe has been characterized by intense heatwaves, with the 2003 heatwave alone causing more than 30,000 deaths. Rising temperatures driven by climate change are now exposing an increasing number of people to a new form of housing vulnerability called 'summer energy poverty', where households struggle to keep their homes cool enough. This warming trend is felt throughout Europe, including atypically affected regions like the United Kingdom.A recent study, published in June 2023 by the Abbé Pierre Foundation in France, revealed that more than half of the French people suffered from heat in their homes, at least once, in 2022. Since the 2003 heatwave, research has been conducted on health risks related to high temperatures. Similar to the case of cold temperature impacts, vulnerable people are those with diabetes or neurological disorders(Vardoulakis *et al.*, 2014; Madrigano *et al.*, 2015). Global warming increases the frequency, intensity and duration of heat waves which is expected to lead to increased summer mortality rates (IPCC, 2013; Abbé Pierre Foundation, 2023; Santé Publique France, 2023).

In Europe, the literature on energy poverty has mainly focused on cold winters and heating issues. A household is energy poor if it encounters difficulties in warming its homes and meeting energy services needs (Boardman, 1991; Devalière, 2007; Hills, 2011; Walker and Day, 2012; Charlier and Legendre, 2019). In countries with extreme summers or tropical climates, an extended definition of energy poverty that addresses the ability of a household to maintain indoor temperatures at safe levels during periods of high heat is necessary (Sanchez *et al.*, 2017). Thus, cooling needs and overheating risks must be incorporated into the energy poverty equation (Moore, 2017; Moore *et al.*, 2017). IIn this study, we aimed to assess the extent to which heatwaves influence the intensity and spatial distribution of energy poverty across climate zones and city sizes in France To measure energy poverty, we use the original thermal discomfort and energy poverty index (DEPI) developed by Rakotomena and Ricci (2024). The originality of the indicator is that it includes a climatic comfort dimension.

Methods

[The thermal discomfort and energy poverty index capture three dimensions of energy poverty: household standard of living, household housing quality, and household climatic comfort. Temperature and humidity are heat-stress factors that define the human sensation of thermal comfort (Fanger, 1970). The DEPI is based on the quadratic mean of the three dimensions:

$$DEPI = \sqrt{\frac{I_P^2 * I_Q^2 * I_C^2}{3}}$$

where I_P is an indicator of the household's standard of living, I_Q is an indicator of poor housing quality, and I_C is an indicator of thermal discomfort. These three dimensions are justified as follows:

- $I_P = \frac{P - Min(P)}{Max(P) - Min(P)}$, where P is the ratio between the poverty threshold (60% of the median disposable income after housing and domestic energy cost per consumption unit) and household's disposable income net of housing and domestic energy costs per consumption unit

- $I_Q = \frac{Q - Min(Q)}{Max(Q) - Min(Q)}$, where Q is the sum of the characteristic scores of a household and is defined as follows:

Variable	**Value**	**Score**
Dwelling with hot water	Yes, No, No running water	0, 0.5, 1
Quality of wall insulation	Good, Average, Poor	0, 0.5, 1

Quality of electrical installation	Good, Poor	0, 1
Dwelling with showers or baths	Yes, No	0, 1
Living in a makeshift dwelling	No, Yes	0, 1

- $I_C = \frac{C - Min(C)}{Max(C) - Min(C)}$, where C measure the thermal discomfort based on Md Din *et al* (2014) formula: $C = T - 0.55(1 - 0.01RH)(T - 1.45)$, with T the temperatures in °C and RH the relative humidity in %.

In this study, to analyze the variation in the intensity of energy poverty, we fixed standard living and housing quality dimensions and varied the climatic dimension over several years (2003, 2006, 2013, 2018, and 2022, where there were heat waves in France, and 2014 and 2021 without heat waves). We will compare the distribution of the DEPI for each year during heatwave periods. We can then attribute the differences between years to climatic dimensions.

Our study uses the 2013 French national housing survey database (the latest available complete dataset on housing data in France) and ERA5 reanalysis (Copernicus EU) for climatic data (with a resolution of 0.1°*0.1°) to measure the effect of heatwave on energy poverty intensity. The aim of the French national housing survey database is to describe housing stock and the conditions of French household's main residences. This survey provides highly detailed information about income, costs of energy, housing costs and quality.]

Results

(Results are in)

Conclusions

(Conclusions are in)

References

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