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On the minimal thermal habitability conditions in low income dwellings in Spain for a new definition of fuel poverty

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ABSTRACT

Fuel poverty can be defined as "the inability to afford adequate warmth in the home". The concept was firstly developed due to health risks related to cold among low income households. However, in the last few decades, especially since the summer heat wave of 2003 that caused 35,000 deaths across Europe, a lot of research has been conducted about the health risks related to high temperatures.

Along with advances in knowledge related to the health risks associated with inadequate temperatures, several directives of the European Commission related to energy regulation urge Member States to develop their own fuel poverty definitions. This need of a methodological development for new definitions poses several questions. First, what should be the temperature thresholds for the overheated season? But, furthermore, are existing temperature baselines adequate for the Spanish context and climate?

This paper presents a preliminary approach to define these new temperature thresholds for the Spanish context through the adaptive comfort model criteria. For that purpose, a statistically representative dwelling building typology of vulnerable household spaces was used to analyze indoor thermal temperatures and hence, to establish minimal energy requirements so as to achieve minimal habitability conditions.

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1. Introduction

1.1. Relevance of research

Fuel poverty is an increasing matter of interest within the EU, as expressed in recent directives [1,2] where the European Commission urges Member States to define their vulnerable citizens as well as to invest in order to tackle fuel poverty [3,4]. In line with these directives, Europe 2020 Strategy takes into account those households unable to afford adequate warmth at home [5].

One of the most severe consequences of fuel poverty is health risks associated with being regularly exposed to excess cold or heat. This has led researchers, governments and activists to focus on fuel poverty. One of the first attempts to define fuel poverty in the UK was presented in the Warm Homes and Energy Conservation Act, which defined fuel poverty as follows:

> 'a person is to be regarded as living 'in fuel poverty' if he is a member of a household living on a lower income in a home which cannot be kept warm at a reasonable cost' [6].

Similarly, the EU statistics on income and living conditions consider 'the ability to keep the home adequately warm'. It must be highlighted that the focus has traditionally been on cold associated diseases while health risks related to high temperatures at home have been less researched until recently.

Many other European countries, such as Ireland [7,8] and France [9] [10], have already established fuel poverty definitions, or have taken first steps to establish a definition of fuel poverty, such as in Romania [11]. Nonetheless, the problem is yet to be defined in most Member States. Developing new definitions of fuel poverty across the EU is challenging, primarily due to the difficulty in extrapolating existing national definitions to other countries arising from differences in climate, income levels, housing stocks and heating

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and cooling systems across Member States.

On the one hand, as a response to these variations across countries and given the increasing interest of researchers in defining the problem, new approaches to fuel poverty have been developed. These studies have focused on particular driving forces of the problem; the energy market deregulation in Eastern post-communist countries [12], the energy transition in Germany [13], the economic recession in Greece [14], household socioeconomic factors in France [15], or building energy performance [16] and type of available energy in Italy [17]. Also, recent definitions of fuel poverty, such as 'the inability to attain a socially and materially necessitated level of domestic energy services' [18] aim to adopt a more holistic approach towards the investigation of the problem by dissolving the traditional dichotomy between 'energy poverty' and 'fuel poverty'.

On the other hand, indoor overheating problems have been identified in studies related to low income households carried out in warmer European countries, such as Portugal [19] and Greece [20], as well as heating dominated countries, such as the UK [21,22].

Taking the above into consideration, new definitions of fuel poverty for Southern European countries should be considered by factoring in regional variations in climate, built environment and socioeconomic characteristics. Climate is a key factor, and hence, new methods should revise temperature baselines for the cold season as well as consider health risks related to high temperatures and delimitate the acceptable thermal conditions for the summer season.

1.2. Aims and objectives of the study

This paper aims to identify the minimal thermal habitability conditions that need to be achieved in low income dwellings in Spain in order to lay the foundations for a new definition of fuel poverty in this country. To this end, the following objectives are set:

- To establish minimal thermal habitability conditions for dwellings
- To evaluate the minimal energy needs related to these thermal habitability conditions
- To compare these minimal energy needs to Spanish regulatory energy demand calculations

2. Fuel poverty and health

Research on the energy performance of low income family dwellings has been undertaken in Germany [23], Greece [24,25], Cyprus [26], Spain [27,28] and Europe as a whole [29]. Households suffering from fuel poverty often have to reduce the use of heating and cooling facilities and, as a result, live under inadequate thermal conditions that may expose them to severe health risks.

2.1. Health risks associated with living under inadequate temperatures

The health risks related to living in cold homes have been widely investigated since the first fuel poverty studies were developed in cold weather countries. Excess winter mortality and its association with the lack of building thermal insulation has been widely studied [30,31].

In 1982, a World Health Organization working group carried out a review of evidence regarding connections between indoor temperatures and health and established that health risks were lower for temperatures between 18 °C and 24 °C [32]. However, this study has been widely criticised because it was not based on specific studies [33]. A later study referred to these temperatures but also established that it was not possible to set the mean temperature below which the population can be considered at risk [34]. A more recent report from the Marmot Review Team presented a summary of existing knowledge regarding cold temperature health impacts [35]. Its main conclusions were as follows: (a) countries with better building thermal insulation levels are characterised by lower excess winter mortality, (b) there is evidence of the relation between excess winter mortality and dwelling low indoor temperature, (c) mental health is also negatively affected by low indoor temperatures.

The importance of health risks related to high temperatures has been increasingly recognised in recent years. The research interest on the adverse impacts of building overheating has been partly triggered by the heat wave of 2003 that caused up to 45,000 deaths in 12 European countries [36]. Before 2003, several studies, some of which conducted for the city of Madrid [37], had already pointed out the relationship between high temperatures and mortality [38]. Similarly to cold temperature impacts, children and older people as well as people suffering from diseases such as diabetes or neurological disorders were found to be more vulnerable to high temperatures. In 1995, the heat wave that took place in Chicago resulted in higher negative impacts amongst the lower socioeconomic level population segments, probably related to worse thermal habitability conditions in dwellings occupied by these parts of the population [39].

Climate change scenarios [40] predict an increase in the frequency and intensity of heat waves, which is likely to lead to a rise in in excess summer mortality. Public health authorities activate mechanisms for the protection of the population based on the temperature that corresponds to the 95th percentile of daily maximum temperature series of summer months. This temperature varies depending on the climate of each location, which indicates the adaptation of the population to the climate they live in Ref. [41]. In line with this adaptation phenomenon, existing studies have found that the relationship between mortality rates and ambient temperature follows a V or a J shape [42]; mortality rises when the environmental temperature decreases or increases from a fixed comfort temperature zone within which minimum mortality occurs. Therefore, the minimum mortality temperature is higher in Mediterranean cities while in northern cities this temperature is lower as shown in Fig. 1. These studies reinforce the idea that populations adapt to the climate they live in. Minimal mortality temperature decreases when latitude increases and vice versa [43].

2.2. Health and thermal comfort

Existing evidence of the close relationship between temperature and health is directly linked to the study of thermal comfort. Some of the first studies relating health and thermal comfort analysed the human body capacity to adapt to a small range of temperatures from 15 °C to 25 °C. Body energy waste is minimum within that interval, which was defined as the 'indifferent metabolism zone' [44].

More recent reports from WHO have suggested that achieving thermal comfort is not only a matter of providing thermal satisfaction but also promoting health [33]. Along these lines, project LARES (*Large Analysis and Review of European housing and health Status*) [45], conducted a review of thermal comfort and energy efficiency studies in ten EU countries with the aim to establish guidelines to protect population health. It also intended to alert governments to the existing evidence of how thermal discomfort in dwellings directly affects health. Results from this project showed a relationship between health problems and lack of thermal comfort, dwelling low energy

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