Field measurement indicates overheating in Finnish apartments during hot summer weather conditions

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The overheating risk was assessed in over 6000 apartments to show indoor overheating during the hot summer. Finland. The findings indicated that during the hot summer, almost all the apartments' indoor temperatures were above 27°C, and one-third of them were above 30°C. New apartments constructed based on the latest building code demonstrated lower overheating risks during the hot summer.

Keywords: Overheating risk, Hot summer, Apartment buildings, Field study, Climate change, Heatwave

Climate change and associated heatwaves

Anthropogenic emissions of greenhouse gases into the atmosphere are increasing global mean temperature [1]. In Finland, a cold-climate Northern country, this warming trend is around two times higher than the global temperature increase [2]. Additionally, global warming is associated with extreme temperatures [3]. The four longest recorded heatwaves in Finland occurred in 2010, 2014, 2018, and 2021 [4]. Projections under the Representative Concentration Pathway (RCP) 4.5 climate model showed an increase in the frequency, intensity, and duration of heatwaves [5]. This can lead to high indoor overheating risks and cause lung malfunctions, blood flow disorders in the human body, cardiovascular diseases, and increase population mortality [6]. In Finland, the premature mortality rate increased among the elderly during heatwaves [7].

Overheating assessment in the apartments

While some level of overheating was observed during the average summer of 2020, significantly higher levels of overheating were experienced during the hot summer of 2021. As **Fig. 1** shows, the average degree hours above 27°C during the summer of 2021 were approximately three times higher than in the average summer of 2020. The dataset for room air temperatures was obtained from field measurements conducted in apartments in the Helsinki region, Finland. The data

consisted of 6974 apartments with hourly data from May 15th to August 31st, 2020, and 6057 apartments from a similar period in 2021.

The degree hours above 27°C in 2021 was higher than 150 Kh which is based on the requirements of the Ministry of the Environment of Finland for new apartment buildings (Ministry of Environment, 2018). This 150 Kh threshold value can be applied in apartments with or without mechanical cooling with all kinds of ventilation systems including natural or mechanical ones.

Moreover, nearly all apartments had maximum hourly temperatures exceeding 27°C throughout the entire summer as **Fig. 2** shows. The overheating levels during the relaxing time (21-8) were quite similar to the overheating during all day in terms of degree hours above 27°C. However, there are almost no degree hours above 32°C during the nights of both summers.

Overheating risks and apartments' age and area

These apartments were constructed between 1902 and 2016. They were clustered into 5 different age categories based on Finnish building code requirement changes. The group, before 1977 represents a period when there was no building code and no requirements for energy efficiency [8]. The first building code came into force in 1977 and set regulations for U-values of the building envelope [9]. In 2003, the regulations for window U-values changed along with a new demand for heat recovery for ventilation [10], [11]. Moreover, the mechanical exhaust ventilation

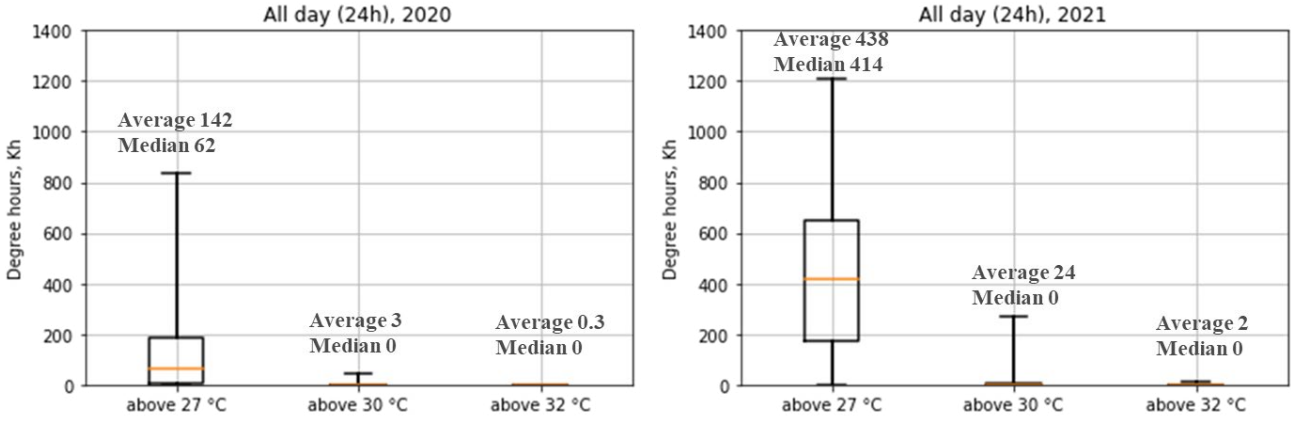

Figure 1. Degree hours above 27°C, 30°C, and 32°C for 98% of the apartments during the whole summer of 2020 and 2021.

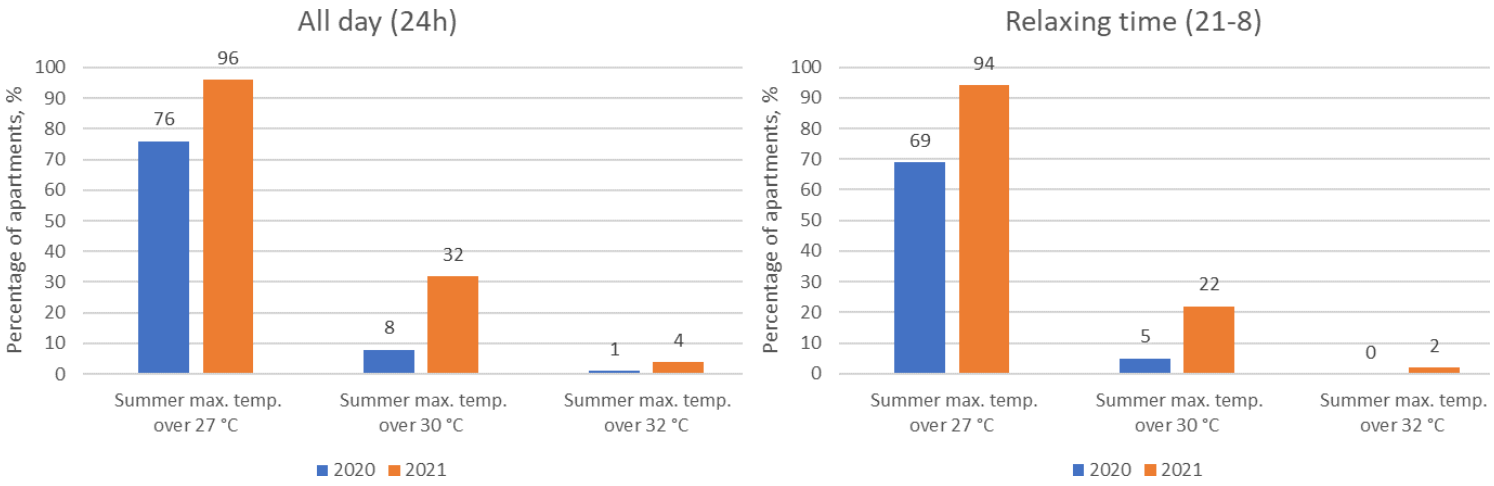

Figure 2. The percentage of apartments with the maximum hourly temperature of the summer above 27°C, 30°C, and 32°C. 6974 apartments in 2020 and 6056 apartments in 2021 are analyzed.

systems without heat recovery changed to mechanical balanced ventilation systems with heat recovery in the buildings designed after 2003 [10], [11]. After that, the simple U-value requirements ended and the new building code in 2010 started to use requirements for total heat losses through the envelope (heat conduction and infiltration) and ventilation [12].

Fig. 3 shows the degree hours above 27°C in different design year groups. The apartments designed based on the latest Finnish building code have a lower risk of overheating with statistically significant differences compared to older apartments. This shows the effectiveness of the latest building codes that require proofed degree hours above 27°C to be lower than 150 Kh during June-August in the new apartment buildings using simulations.

The area of these apartments varied between 20 to 232 m². **Fig. 4** shows the degree hours above 27°C in different area groups. As can be seen, the smaller apartments were at a slightly higher risk of overheating with statistically significant differences compared to the ones with a larger area.

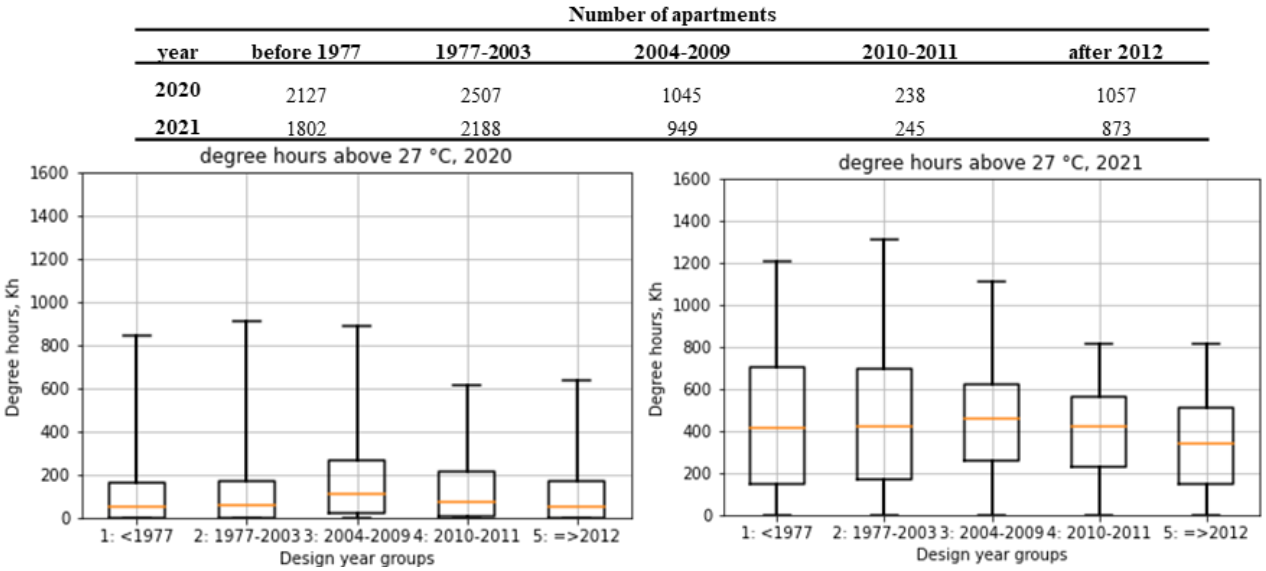

Figure 3. Degree hours above 27°C, 30°C, and 32°C for different design year categories.

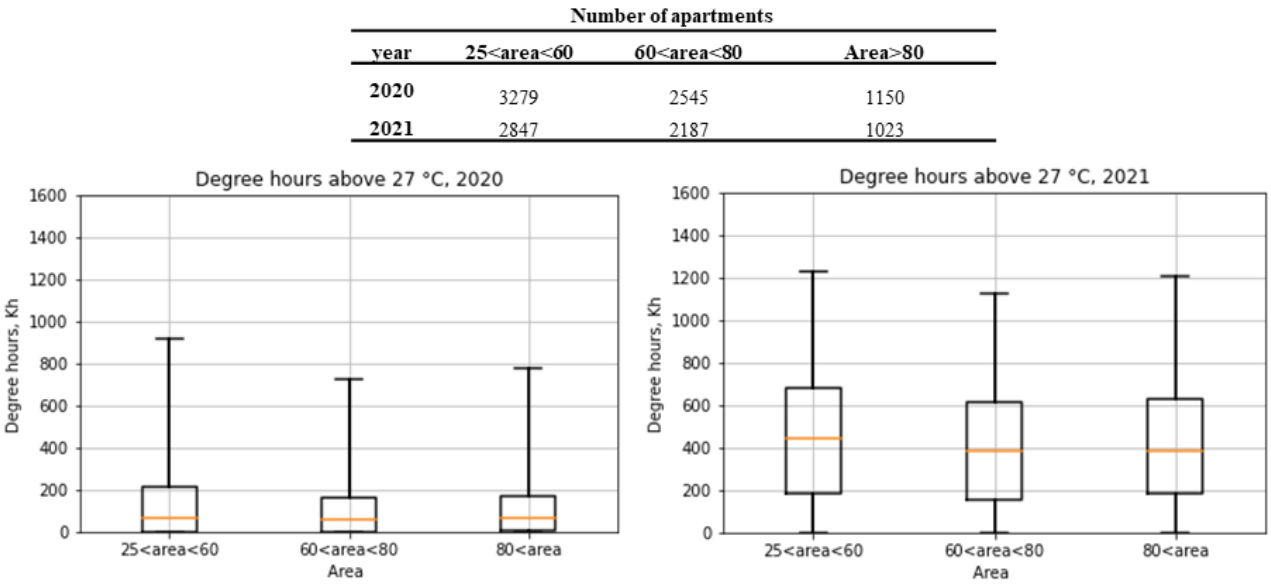

Figure 4. Degree hours above 27°C, 30°C, and 32°C for different area groups.

Conclusions

This study, along with other research conducted in different climates, demonstrates the significant severe overheating in residential spaces of cold climates during heatwaves in the current climate. Although the risk is lower in new apartments designed to mitigate overheating based on the latest Finnish building code, there is an urgent need for actions to prevent indoor summertime overheating. With the rising effects of climate change and its associated heatwaves, these actions could encompass revising design principles in light of climate change, implementing passive strategies and mechanical cooling systems, and imparting education to occupants on their role in averting indoor overheating. ■

References

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