Proceedings of 11th Master Conference: People and Buildings
University of Westminster, 16th September 2022
Network for Comfort & Energy Use in Buildings: https://www.nceub.org.uk

Assessing the effectiveness of passive cooling design strategies to reduce overheating in epilepsy care homes in the UK

Siva Sai Varsha Kakuturu[1], Zoe Upton[2], Lisa Clayton[2], Sanjay Sisodiya[2], Anna Mavrogianni[3]

[1]MSc Health, Wellbeing and Sustainable Buildings, University College London, UK, varshakakuturu@gmail.com
[2]Department of Clinical and Experimental Epilepsy, UCL Queen Square Institute of Neurology, UCL, s.sisodiya@ucl.ac.uk, zoe.upton.21@ucl.ac.uk, lisa.clayton@ucl.ac.uk
[3] Bartlett School of Environment, Energy & Resources, UCL, a.mavrogianni@ucl.ac.uk

Abstract: Under a changing climate, indoor overheating in care settings is becoming a growing problem. In epilepsy care facilities, there has been evidence that high temperatures may increase seizure activity. This study evaluates the risks of overheating in care settings for epilepsy in the UK for present and future climate change scenarios and examines the impact of passive cooling strategies to mitigate overheating. Indoor overheating assessment was carried out using dynamic thermal modelling software. In the current climate scenario, the most efficient combination strategies for reducing overheating were night ventilation, shading, and high albedo surfaces. Under future climate change scenarios of 2050s and 2080s, passive cooling techniques did not fully eliminate the risks of overheating in bedrooms at night-time. The findings of this study can be useful for the design of care settings under climate change and can inform heat management guidance for public health professionals and care home managers.
Keywords: Overheating, Epilepsy, Care Homes, Passive Design Strategies, Dynamic Thermal Modelling

1. Introduction and existing research

Anthropogenic climate change is recognised as humanity's greatest challenge and is expected to rise the incidence of heatwaves globally (IPCC, 2022). Increasing ambient temperatures could lead to overheating inside buildings, which could have detrimental effects on human health and wellbeing (Pachauri *et al.*, 2014). There is a well-established relationship between ambient temperature increases and a rise in heat-related mortality (Arbuthnott and Hajat, 2017). According to recent studies, the excess death rates observed in 2020 in the UK were similar to the previous heatwaves of 2003 (UKHSA, 2022a). Due to physiological limitations in managing the body's temperature, excessive heat can have serious health effects, including dehydration, heat exhaustion and heat stroke (UKHSA, 2022b). Older people, individuals with co-morbidities and inhabitants of care homes, in particular, are likely to be more vulnerable to heat-related health impacts linked to indoor heat exposure as the majority of them tends to spend most of their time indoors (Hughes and Natarajan, 2019).

According to a survey by the Epilepsy Society (2020), 62% of people with uncontrolled seizures experience increased seizure activity during periods of unusually hot weather. Climate change worsens the health of people with epilepsy by causing fever, stress, the ineffectiveness of anti-seizure medications, lack of sleep, and weariness (Gulcebi *et al.*, 2021). Therefore, it is crucial to keep residents with epilepsy from being too hot or thermally uncomfortable.

In recent years, there has been a growing body of literature testing the effectiveness of low carbon cooling strategies to reduce indoor overheating in care settings, such as passive ventilation through occupant controlled window opening (Tsoulou *et al.*, 2022). In order to prevent the penetration of heat indoors, using exterior shading devices, such as external shutters, is advised (Gupta and Gregg, 2017; Oikonomou *et al.*, 2020). However, there is a research gap currently as there is little literature on how to mitigate overheating in care facilities specifically designed for people with epilepsy.

1.1 Aims

The **aims** of this study are twofold:

(i) To investigate the effectiveness of a range of passive building retrofit and operation strategies using dynamic thermal modelling to mitigate the effects of indoor overheating and maintain a thermally comfortable and healthy indoor environment in care homes for people with epilepsy, under the current climate.

(ii) To examine if these passive design strategies can adequately mitigate the risks of overheating under future climate change scenarios.

2. Methodology

2.1 Case study

The study was conducted in a care facility completed in 2009 with 20 long-term residents with epilepsy. The building consists of two blocks, each with two floors. Each floor of the building has four to five apartments with shared living and dining areas. Each single-occupancy room includes a bathroom and storage space right next to it. To evaluate the effects of floor level and orientation, a number of rooms were chosen for this study, shown in Figures 1 and 2.

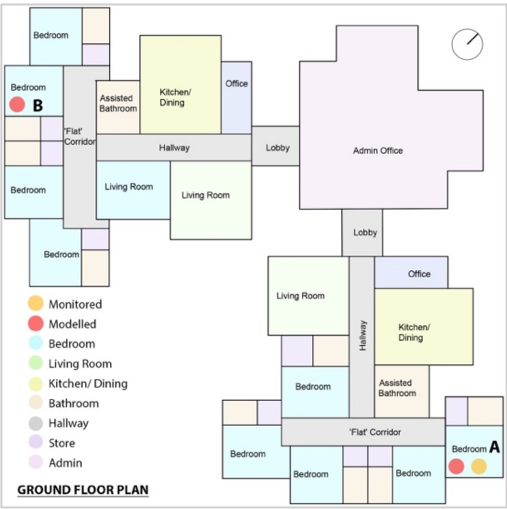

Figure 1. Ground Floor Plan

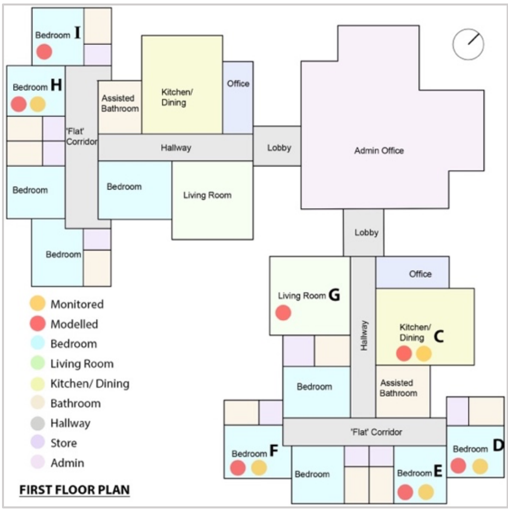

Figure 2. First Floor Plan

2.2 Data Collection

Site visits were conducted to collect information regarding construction materials; floor plan layouts; occupancy, appliances use and window operation schedules.

2.3 Thermal simulation approach – Baseline model

A baseline thermal model was created using DesignBuilder Software Ltd (2022) version 7. Occupancy, light and appliances use, and window operation schedules were initially determined based on CIBSE TM59 and further modified input from care staff and observations made during site visits. The base case construction parameters are shown in Table 1. The thermal model visualizations from Design Builder are represented in Figures 3 and 4.

Table 1. Construction modelling parameters

	Surface	Material	U-Value (W/m²K)
1	Exterior Wall	105mm Brickwork outer + 25 mm Air Gap + 90 mm Insulation + 100 mm Concrete Block+ 13 mm Plaster	0.300
2	Pitched Roof	22 mm Clay tile roofing + 20 mm air gap + 5 mm roofing felt	2.930
3	Internal Partitions	13mm plaster + 115 mm single leaf brick + 13mm plaster	1.960
4	Ground Floor	100mm foam+ 100 cast concrete+ 70mm floor screed + 30mmTimber flooring	0.314
5	Internal Floor	300mm concrete slab	2.060
	Window Glazing	Dbl Clr 6mm/6mm Air	3.094

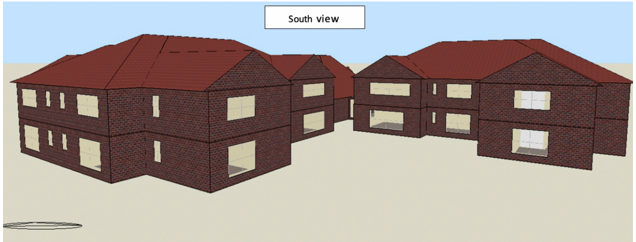

Figure 3. South view of 3D model

Figure 4. Southwest view of 3D model

2.4 Weather Data

Current and future weather files available from the PROMETHEUS project (2011), which are based on the UK Climate Projections (UKCP, 2022) were used to assess the resilience of the case study building to climate change. For the current climate, CIBSE TM59 (2017) suggests the use of Design Summer Year 1 (DSY1) 2020s, High Emissions, 50th percentile scenario. To assess future climate performance, the DSY1 2050s High Emissions (a1fi) 90th percentile and DSY1 2080s High Emissions (a1fi) 90th percentile scenarios were chosen.

2.5 Passive design strategies to mitigate overheating

A series of passive design techniques, previously developed in the context of the ongoing ClimaCare project (Oikonomou *et al.*, 2020), were tested to evaluate the impact of each strategy on reducing overheating. The cumulative impact of the individual strategies was then assessed using combined strategies for the current and future climate scenarios. The list of passive adaptation strategies is listed in Table 2.

2.6 Overheating assessment criteria

Indoor overheating was assessed on the basis of indoor temperatures exceeding the UKHSA's 26°C upper threshold for care settings (2022b).

Table 2. Passive adaptation strategies (ClimaCare, 2022)(Oikonomou et al., 2020)

Category	No	Strategy
A. Baseline	S0	Base case scenario
B. Minimise internal gains	S1	Usage of energy efficient lighting fixtures by replacing
C. Keeping the heat out	S2	Using high albedo walls and roof.
	S3	High reflectivity curtains closed when exposed to the sun
	S4	Spectrally selective, low-e double glazing
	S5	Externally insulated roof and wall
	S6	Windows louvres/side fins (0.5m projections)
	S7	Movable shutters with high reflectivity slats
D. Manage heat	S8	Increase thermal mass of internal partition using thermally heavyweight materials

E. Passive Ventilation	S9	Increasing night ventilation
	S10	Increase window openable areas to 30%
Combination Strategies	C1	Increase window areas to 30% + internal partition thermal mass (S10 + S8)
	C2	All ventilation strategies (daytime passive ventilation + night ventilation)
	C3	Night ventilation + fixed shading + daytime passive ventilation (S10 + S7)
	C4	Night ventilation + movable shading + daytime passive ventilation (S10 + S8)
	C5	All combination strategies (C4 + S4 + S2)

3. Results

3.1 Assessing overheating for base case

For the base case, the percentage of hours above the UKHSA (2022b) 26ºC threshold are shown in Figure 5. Bedroom E has highest percentage of hours above 26ºC threshold at 26% facing South-East in the current scenario, followed by Bedroom F at 24% facing South-West and Bedroom H at 23% facing South-West. The lowest hours of overheating were observed in Bedroom A at 15% facing North-East. Overheating hours increased in Bedroom D on the first floor at 22% in comparison to Bedroom A below with only 15% on the ground floor. Similar trends are noticed across the future scenarios. For the passive design strategies, the most overheated bedrooms (E, F and H) are selected for further study.

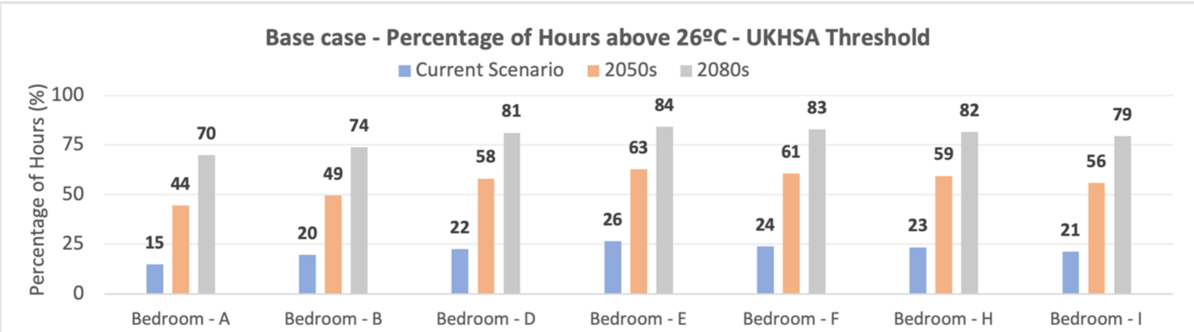

Figure 5. Base case percentage of hours above 26ºC UKHSA threshold

3.2 Assessing the impact of passive design strategies for current scenario

Results for individual strategies S1-S10 and combined strategies C1-C5 are illustrated in Figure 6. All individual strategies except S5 and S8 result in a reduction of overheating hours in comparison to the base case. Night ventilation (S9) was the most effective individual strategy with a 13% reduction in overheating hours. Shading strategies S6 and S7 were the next most impactful resulting in a 11-13% reduction. The next most effective individual strategies were reducing internal gains (S1), reflective curtains (S3), special glazing (S4), increasing window opening (S10) and high albedo materials (S2).

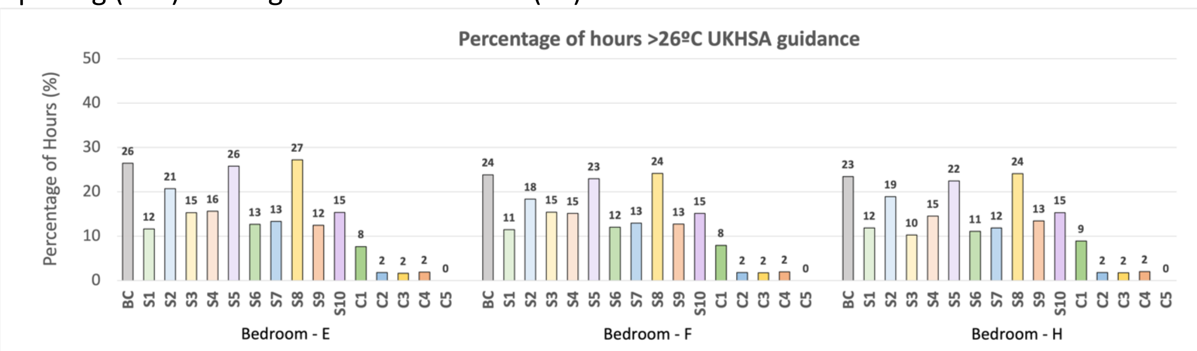

Figure 6. Percentage of hours above 26ºC UKHSA threshold for passive design strategies for current scenario

Across the combined strategies, the most effective strategies are C5 with shading, ventilation, spectrally selective, low-e double glazing, and high albedo materials with 0% hours above the given threshold. The next most suitable are C3, C4 and C2 with ventilation and shading strategies at 2% above threshold.

3.3 Assessing the impact of combination design strategies for current and future scenarios

Figure 7 illustrates the performance of the modelled rooms under the future climate change scenarios. Overall, the percentage of overheating hours in all bedrooms increases in the 2050s and 2080s. Strategy C5 is still the most effective with 23-28% of hours above threshold followed by C4, C3 and C2. In conclusion, the worst performing strategy C1 leads to approximately 30% reduction in overheating while the best performing strategy C5 results in 60% reduction in comparison to the base case in all the bedrooms and all climatic scenarios.

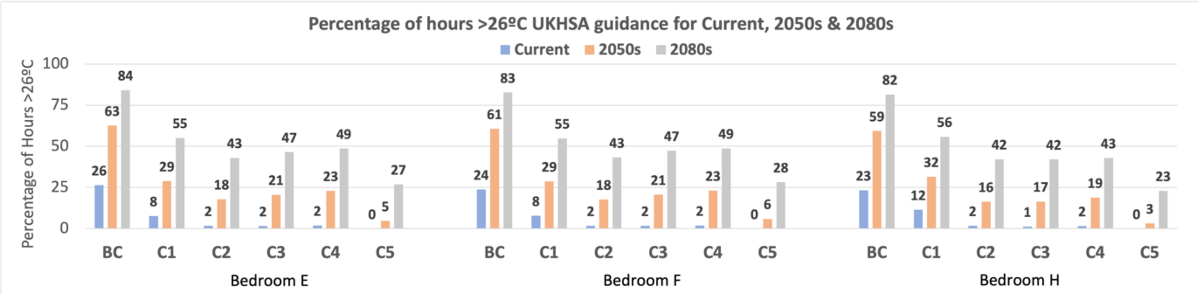

Figure 7. Combination strategies for current and future scenarios

4. Discussion

The findings emerging from this study show that overheating is a growing problem in care settings. In the case study care setting for people with epilepsy, even under the current climate (2020s), all the rooms are overheating to varied degrees. Passive cooling measures were found to significantly decrease summer indoor temperatures.

In the base scenario, orientation also influences overheating risk, with bedrooms facing south-east and south-west unsurprisingly experiencing higher levels of overheating than those with other orientations as their facades are more exposed to sun radiation. The findings also reveal that, while facing the same direction, first floor rooms experience more overheating hours than rooms on the ground floor, which is in agreement with the findings of other studies (Baborska-Narożny *et al.,* 2017). This could be because ground floor units are less exposed to the outside environment than top floor units.

To determine the potential impact on the reduction of overheating, passive and adaptive measures were investigated. Night ventilation (S9) was the most effective and potentially cost-efficient adaptation approach for reducing overheating with the greatest reduction in overheating hours across all rooms. The next best performing individual passive approach to prevent overheating is adjustable (S7) and fixed (S6) shading. The combination of night ventilation, movable shading, high albedo materials, and efficient glazing (C5) was the most effective strategy with 0% hours above the recommended upper threshold under the current climate. It was shown that in the future scenarios of 2050s and 2080s, while passive measures reduced indoor temperatures, they did not fully eliminate overheating risk. At this stage, hybrid and active cooling strategies may need to be considered to attain thermal comfort.

5. Conclusion

This study assessed indoor overheating risk in a case study care facility for people with epilepsy under present and future climatic conditions and quantified the effectiveness of a wide range of passive design strategies to minimise overheating using dynamic thermal modelling. It was shown that maintaining indoor temperatures below the threshold of 26°C using a combination of passive design measures could be achieved for the current climate. For future 2050s and 2080s climate scenarios, passive strategies will help reduce temperature but might have to be considered in the context of hybrid cooling systems. This paper raises questions about how well-prepared care settings are for high temperatures and climate change, and it offers important additional information about summertime temperatures and overheating for present and future scenarios in epilepsy care settings. The findings can assist construction professionals, policymakers and public health researchers to create policy and guidelines for the climate change adaptation of care settings. This study also sets the framework for future studies on overheating in care facilities where residents may be dealing with different medical issues that are exacerbated by rising temperatures.

6. References

Arbuthnott, K. G. and Hajat, S. (2017) 'The health effects of hotter summers and heat waves in the population of the United Kingdom: A review of the evidence', Environmental Health: A Global Access Science Source. BioMed Central Ltd. doi: 10.1186/s12940-017-0322-5.

Baborska-Narożny, M., Stevenson, F. and Grudzińska, M. (2017) 'Overheating in retrofitted flats: occupant practices, learning and interventions', Building Research and Information, 45(1–2), pp. 40–59. doi: 10.1080/09613218.2016.1226671.

Christidis, N., Jones, G. S. and Stott, P. A. (2014) 'Dramatically increasing chance of extremely hot summers since the 2003 European heatwave', Nature Climate Change 2014 5:1, 5(1), pp. 46–50. doi: 10.1038/nclimate2468.

CIBSE TM59 (2017) Design methodology for the assessment of overheating risk in homes. Chartered Institution of Building Services Engineers.

ClimaCare (2022) ClimaCare: Climate Resilience of Care Settings -. Available at: https://www.ukclimateresilience.org/projects/climacare-climate-resilience-of-care-settings/ (Accessed: 25 July 2022).

DesignBuilder Software Ltd (2022) DesignBuilder Software Ltd - What's New in v7. Available at: https://designbuilder.co.uk/software/what-s-new-in-v7 (Accessed: 22 July 2022).

Epilepsy Society (2020) Seizures and hot summers | Epilepsy Society. Available at: https://epilepsysociety.org.uk/news/seizures-and-hot-summers (Accessed: 12 June 2022).

Gulcebi, M. I. et al. (2021) 'Climate change and epilepsy: Insights from clinical and basic science studies', Epilepsy and Behavior. Academic Press Inc. doi: 10.1016/j.yebeh.2021.107791.

Gupta, R. and Gregg, M. (2017) 'Care provision fit for a warming climate', Architectural Science Review, 60(4), pp. 275–285. doi: 10.1080/00038628.2017.1336984.

Hughes, C. and Natarajan, S. (2019) 'Summer thermal comfort and overheating in the elderly':, https://doi.org/10.1177/0143624419844518, 40(4), pp. 426–445. doi: 10.1177/0143624419844518.

IPCC (2022) 'Climate Change 2022: Impacts, Adaptation and Vulnerability'. doi: 10.1017/9781009325844.002.

Oikonomou, E. et al. (2020) Assessing heat vulnerability in London care settings: case studies of adaptation to climate change.

Pachauri, R. K. et al. (2014) 'Climate Change Synthesis Report'. Available at: http://www.ipcc.ch. (Accessed: 7 August 2022).

PROMETHEUS (2011) PROMETHEUS - University of Exeter. Available at: https://emps.exeter.ac.uk/engineering/research/cee/research/prometheus/ (Accessed: 28 July 2022).

Tsoulou, I. et al. (2022) Assessing the Current and Future Risk of Overheating in London's Care Homes: The Effect of Passive Ventilation.

UKCP (2022) UK Climate Projections (UKCP) - Met Office. Available at: https://www.metoffice.gov.uk/research/approach/collaboration/ukcp (Accessed: 5 September 2022).

UKHSA (2022a) Heat mortality monitoring report: 2020 - GOV.UK. Available at: https://www.gov.uk/government/publications/heat-mortality-monitoring-reports/heat-mortality-monitoring-report-2020 (Accessed: 7 August 2022).

UKHSA (2022b) UK Health Security Agency - Heatwave plan for England - Protecting health and reducing harm from severe heat and heatwaves.