Heat resilience in healthcare systems

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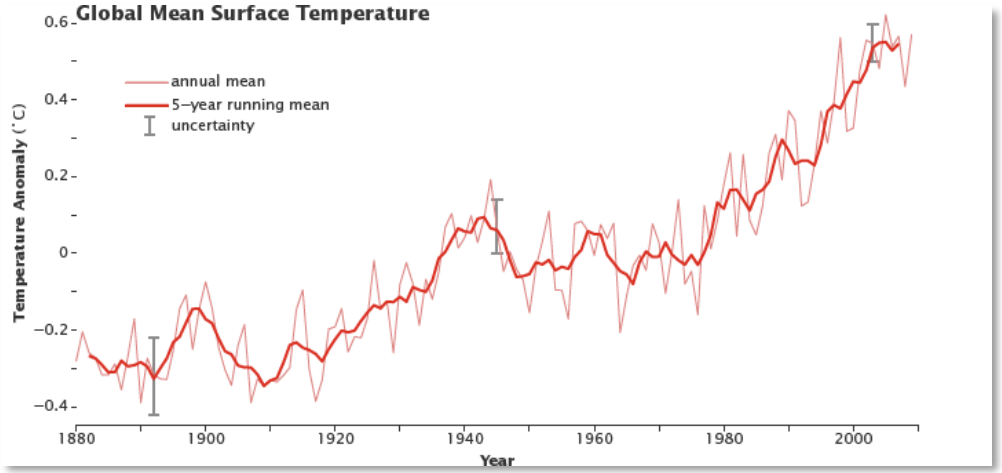
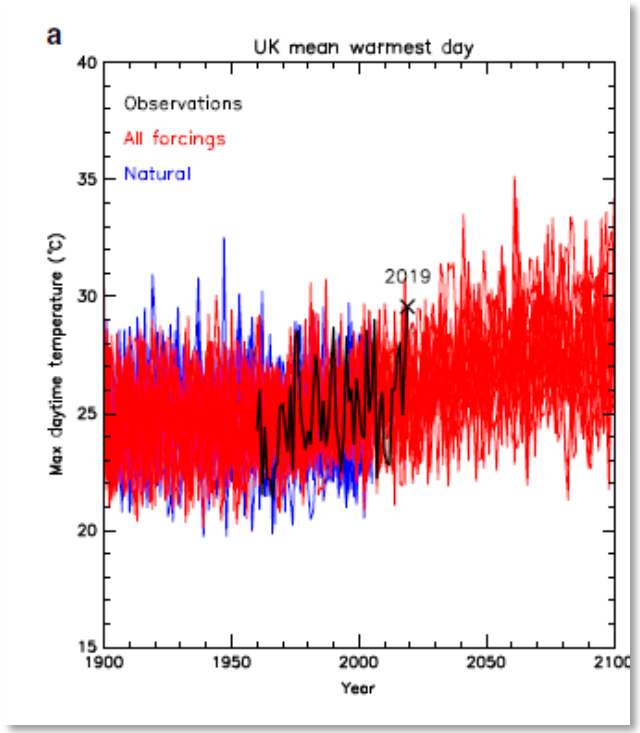
Session Outline

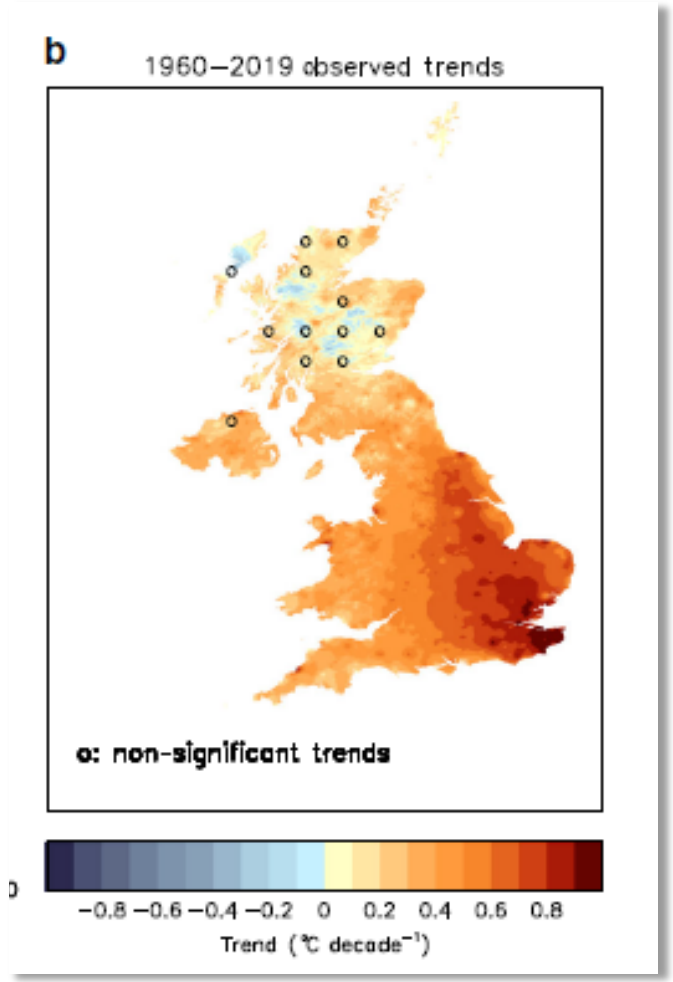
- Investigate climate change.
- Impacts of heatwaves on healthcare.
- Adaptation strategies to heatwaves.
- Implementing Digital Twins to improve heatwave resilience in healthcare. Research project: the role of digital twins to optimise hospital resilience strategies to heatwaves.

Climate change



Source : https://earthobservatory.nasa.gov/features/GlobalWarming/page2.php





Source: Christidis et al., 2020

Impacts of heatwaves on healthcare

Elderly Mortality Rate Linked to Heatwaves – Doubled between 2016/17 to 2021/22.
Source: Kovats, et al., 2021; Gupta, et al., 2016)

Impact on Human - Dehydration, heat stroke and distress to patients, visitors, and staff & accelerated death

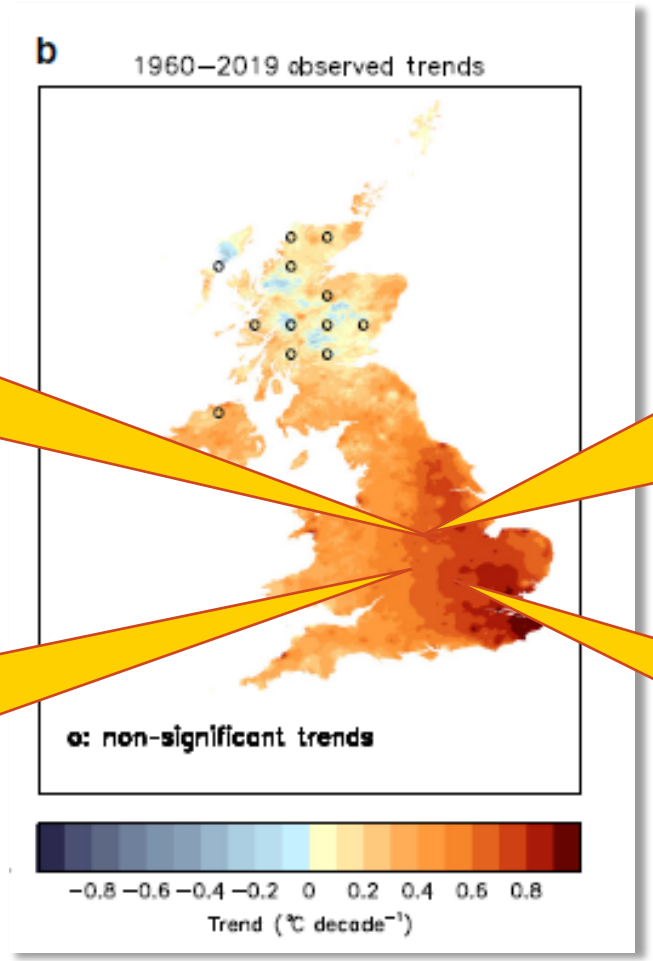
Impact on assets –Equipment failure, disruption of infrastructure and solar glare. Source: (Kovats, et al., 2021)

Hospital Admissions - Hot days admission is increasing by leaps and bounds. Source: Brooks et al., 2023; Jeffery, J., 2023

Impacts of heatwaves on healthcare

Overheating incidents within hospitals has almost doubled in the last 5 years.
Source: Tidman, 2023

In 2020, NHS reported 6,822 overheating incidents in 2022/23.
Source: Bawden, 2023



The 2022 heatwave led to one-fifth of UK hospitals cancelling operations over three days of extreme temperatures.

90% of hospital wards are at risk of overheating.
Source: Short, 2014)

Adaptation Strategies to Heatwaves

- Restricting surgical activity to day cases — Source: Stokel-Walker, 2022
- Delaying discharge of high-risk patients — Source: Stokel-Walker, 2022
- Distributing portable fans to patients and staff — Source: Brooks et al., 2023
- Turning off unnecessary lights and equipment — Source: Brooks et al., 2023
- Giving longer staff breaks and extra fluids — Source: Stokel-Walker, 2022
- Shading patients — Source: Brooks et al., 2023

Providing fans & mobile AC

Source: https://www.nhstayside.scot.nhs.uk/News/Article/index.htm?article=PROD_303139

Delivering of ice-creams

Source: https://www.pennmedicine.org/news/internal-newsletters/happenings/2020/july/ice-cream

Adaptation Strategies to Heatwaves

Distributing portable fans to patients and staff – Not all wards can adopt (infection control and health & safety)

Restricting surgical activity to day cases – Creating backlog of surgical activities

Delaying discharge of high-risk patients – Increasing demands for beds for new patients

Shading patients - Depending on size of hospital estates to have extra space dedicated as cooling space

Giving longer staff breaks – Decreasing quality of service & increase patient waiting time

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Research project: the role of digital twins to optimise hospital resilience strategies to heatwaves

Pascale, F., Bawuah, D. & Achour, N.

Source: https://www.techyv.com/article/what-is-digital-twin-where-it-used/

NHS
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NHS Foundation Trust

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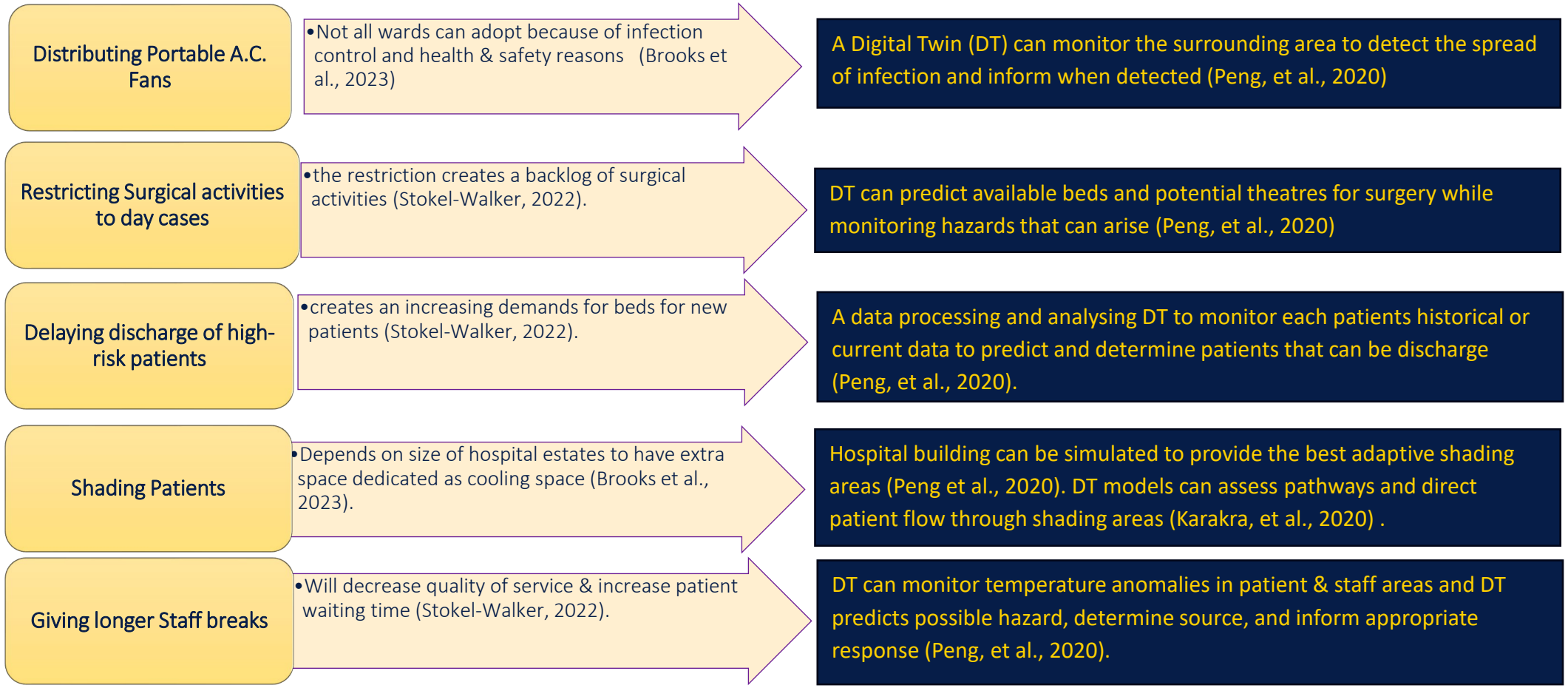
Project steps

- A literature review: How can DT support hospital resilience strategies to heatwaves
- An online workshop was organised and conducted to:
  - correlate challenges caused by heatwaves and extreme weather events
  - understand how the Trust's existing resilience strategies regulated the threat; and
  - Investigate the potential to adopt DT to improve hospital resilience to heatwaves.
- Two wards are currently monitored to evaluate internal hourly temperature.
- CAD data have been collected to develop the DT model in Integrated Environmental Solutions (IES).
- DT model will be validated during a final workshop.

How can DT support hospital resilience strategies to heatwaves? A literature review



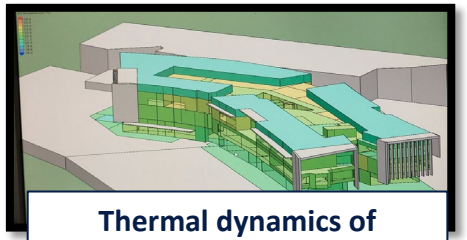
Impacts and challenges created by heatwaves (workshop results)

Hospital Components	Heatwave Impacts	Heatwave Impacts rationale	Challenges
Building	**Impact on indoor comfort**	Due to the type of building envelope and building forms, most of the aged NHS estates retain more heat during the day, which is emitted into internal spaces (wards, offices, etc.), raising temperatures beyond comfort levels.	**Building envelope and form** - They have been designed to address winter conditions and retain heat.
	Impact on internal temperature	Some facilities are more susceptible to overheating due to their orientation, particularly those facing south or north.	**Building orientation** - Facilities that are designed with their essential services facing south are more vulnerable to rising temperatures because of increased heat absorption.
Equipment	**Need for rented air conditioning**	Because of the increased temperature, hospitals are required to rent air conditioning units, incorporating them into hospital cooling systems.	**Extra power consumption** - The reliance on rented cooling equipment, such as air conditioning, significantly increases electric power demand, raising the risk of system overload.
	Impact on HVAC system	The chillers' ambient thermal working capacity is set between 25-28°C, but heatwave temperatures have been known to exceed 40°C.	**Maintaining efficient chiller operation when ambient temperatures exceed their designed limits** -
		Need to overuse of AC & fans due to limited resources.	**Excess stress on cooling equipment** - Limited resources have led to the challenge of overworked and overused equipment, resulting in inadequate cooling across all areas.
	Equipment generate waste heat	During heatwaves, Medical and cooling equipment can become hotter than usual due to conduction. This increases the internal temperature and disrupts thermal comfort.	**Maintaining equipment during operation when it cannot be adequately cooled and is radiating excessive heat**
	Impact of noise and air quality	The use of mobile air conditioning units and other cooling appliances can generate undesirable noise and ineffective airflow, compromising air quality if not adequately vented.	**Inability to adapt mobile units** - Whether rented or purchased, it is challenging to seamlessly integrate mobile units with the existing cooling system while ensuring proper installation.
Governance	**Impact on medical and ancillary services**	Services (like medicine manufacturing, intensive care units and pharmacy department) are at risk if temperatures are not kept within legal requirements	**Certain medical and ancillary services are not able to operate as temperatures go above legal requirements**
	Impact on finance	From renting to buying or maintaining equipment to retrofitting and adaptation processes, all involve investment.	**Competing needs and financial constraints make the required investment difficult.**
Staff & Patients	**Impact on patients' condition**	Heatwaves can worsen health risks in chronic patients and the elderly, potentially leading to death.	**Limited resources** - Some non-critical patients wards are not adequately resourced, which can worsen their condition.
	Impact of Staff Wellbeing	Due to limited resources, hospitals often neglect non-patient-facing areas, such as offices. This has led to backlash, with some staff feeling dejected.	**Unwanted Inequality** - The existing inequalities among staff are fostering discontent and creating unhealthy competition for resources between clinical and non-clinical teams.
		Working long hours in a heatwave can impact on staff health and wellbeing, causing fatigue, dehydration, and heat stroke	**Reduced staff wellbeing and productivity** - Long-hour shift pattern poses significant challenges during heatwaves.
		Certain clothing increases the risk of heat discomfort by acting as a barrier to the body losing heat.	**Cost of providing suitable summertime clothing for staff also not all hospital services can conform to clothing that reduce heat gain.**
	Impact on logistics	Services, patients or equipment are moved to different locations	**Extra costs, personnel, and time that could have been allocated to other duties.**
Supplies	**Impact on procurement**	Cost of renting due to competition from other hospitals and institutions.	**Cost and storage -** Most UK hospitals face financial difficulties and storage challenges, leading them to rent equipment instead of purchasing and seek external storage solutions.

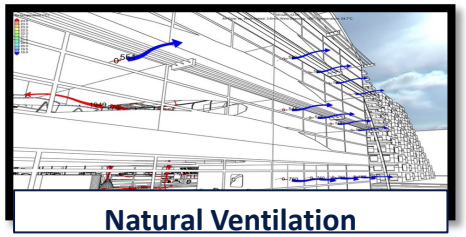
Potential applications of DT to improve heatwave resilience in hospitals (workshop results)

Function of technology	Rationale	Hospital Components
Real-time monitoring	Monitoring the impact of heatwaves on the building, equipment, and the ambient comfort of staff & patients.	Building and equipment
Sensors-informed simulation	Supporting long-term built asset management by simulating impacts of climate change on the building stock, assess the effectiveness of climate adaptation measures, and optimize the climate adaptation strategies.	
Forecasting	Forecasting high temperatures that can impact processes and services within the building as well as those that can potentially damage equipment or exacerbate illness	Equipment, Staff & Patients
	Providing a longer time to implement emergency procurement options.	Governance & Supply

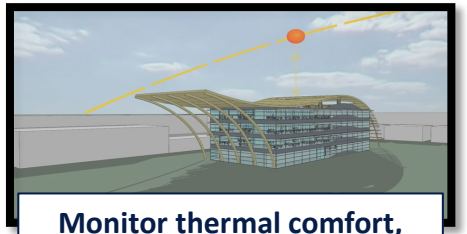
Potential interaction between DT and adaptation Strategies to Heatwaves



Thermal dynamics of buildings



Natural Ventilation



Monitor thermal comfort, loads and effective shading

Glint and glare effect

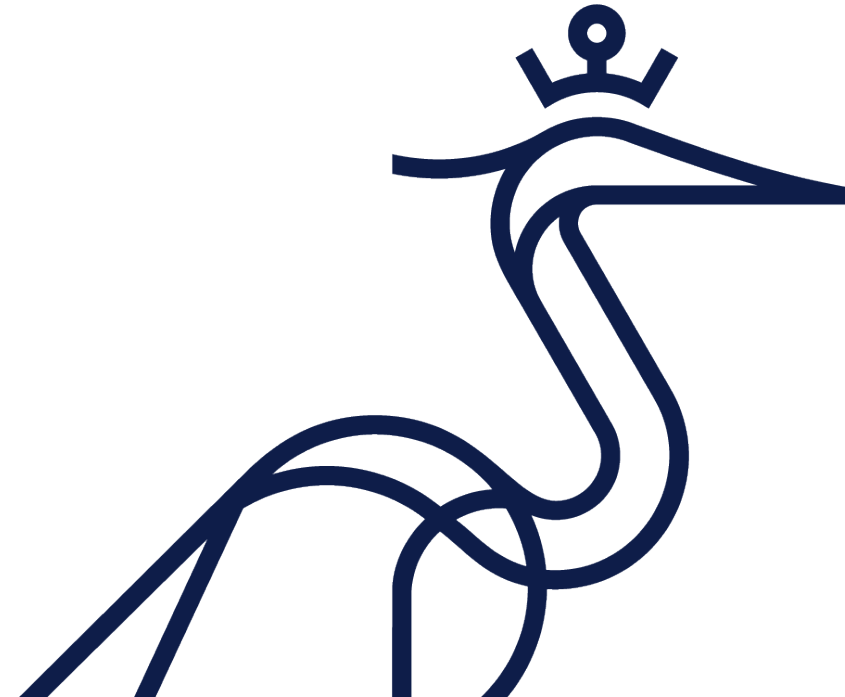
- Solar shading/glazing
- Green roofs, roof pond & green facades
- Ventilative & evaporative roof and cooling
- Thermal Mass including PCMs
- Personal comfort systems
- Compression & absorption refrigeration
- Ground source cooling

Conclusions

- Projections indicate that, by 2100, the UK could experience temperatures reaching up to 40˚C as a result of persistently high carbon emissions, highlighting the urgent need for climate action.
- Heatwaves pose significant risks to public health, leading to increased hospital admissions and straining healthcare resources, necessitating proactive measures to mitigate these impacts.
- Current hospital adaptation strategies regarding heatwaves are primarily reactive, which limits their effectiveness in building long-term resilience; a shift towards proactive strategies is essential for better preparedness.
- Digital Twins offer a promising solution to enhance hospital resilience against heatwaves. By enabling real-time monitoring and utilizing sensor-driven simulations and forecasting, they can significantly improve response capabilities.
- Leveraging Digital Twins can optimize the implementation of effective adaptation strategies for buildings, ensuring more sustainable and resilient infrastructure in the face of rising temperatures.

Thank you for your attention!

Any questions?



Reference list

- Bawden A., (2023). Overheating and flooding at hospitals in England 'pose threat to patient safety. The Guardian. Available at: https://www.theguardian.com/society/2023/dec/27/overheating-and-flooding-at-hospitals-in-england-poses-threat-to-patient-safety#:~:text=In%20the%20year%20to%20April,2%2C980%20recorded%20in%202016%2D17
- Brooks K, Landeg O, Kovats S, et al., 2023. Heatwaves, hospitals and health system resilience in England: a qualitative assessment of frontline perspectives from the hot summer of 2019. Available at: https://bmjopen.bmj.com/content/bmjopen/13/3/e068298.full.pdf
- Christidis, N., McCarthy, M. & Stott, P.A. The increasing likelihood of temperatures above 30 to 40 ˚C in the United Kingdom. Nat Commun 11, 3093 (2020). https://doi.org/10.1038/s41467-020-16834-0.
- Gupta, R., Walker, G., Lewis, A., Barnfield, L., Gregg, M., Neven, L., 2016. Care provision fit for a future climate. Joseph Rowntree Foundation. Available at: https://www.jrf.org.uk/report/care-provision-fit-future-climate (Accessed: 08 August 2023)
- Jeffery, J., 2023. NHS Overheating: Analysis of the impact of heatwaves on the people who rely on and work in the NHS. Round Our Way. Available at: https://static1.squarespace.com/static/6391e85d016fa00803f1c14d/t/649aec54f32c912fa7c343bb/1687874667248/NHS+OVERHEATING+-+Round+Our+Way+report+-+June+2023+-+FINAL.pdf
- A. Karakra, F. Fontanili, E. Lamine and J. Lamothe, "HospiT'Win: A Predictive Simulation-Based Digital Twin for Patients Pathways in Hospital," 2019 IEEE EMBS International Conference on Biomedical & Health Informatics (BHI), Chicago, IL, USA, 2019, pp. 1-4, doi: 10.1109/BHI.2019.8834534.
- Kovats, S. and Brisley, R. 2021. Health, communities and the built environment. In: The Third UK Climate Change Risk Assessment Technical Report [Betts, R.A., Haward, A.B., Pearson, K.V. (eds.)]. Prepared for the Climate Change Committee, London. Available at: https://www.ukclimaterisk.org/wp-content/uploads/2021/06/CCRA3-Chapter-5-FINAL.pdf
- Peng, Y., Zhang, M., Yu, F., Xu, J. and Gao, S. (2020). Digital Twin Hospital Buildings: An Exemplary Case Study through Continuous Lifecycle Integration. Advances in Civil Engineering, 2020, pp.1–13. doi:https://doi.org/10.1155/2020/8846667
- Short, A., Noakes, C. J., Gilkeson, C. A., Fair, A. (2014), "Functional recovery of a resilient hospital type", Building Research & Information, Vol. 42 No. 6, pp. 657-684, doi: https://doi.org/10.1080/09613218.2014.926605.
- Stokel-Walker, C., 2022. 'Why do NHS hospitals struggle to handle heatwaves?' https://doi.org/10.1136/bmj.o1772 [Accessed: 18 April 2023]
- Tidman, Z., (2023). Overheating incidents nearly double across NHS estates. Health Service Journal. Available at: https://www.hsj.co.uk/service-redesign/overheating-incidents-nearly-double-across-nhs-estates/7034212.article#:~:text=An%20overheating%20incident%20is%20when,the%20safety%20of%20vulnerable%20patients