Care provision fit for a future climate

by Rajat Gupta, Gordon Walker, Alan Lewis,
Laura Barnfield, Matt Gregg and Louis Neven

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How far are existing care homes and other care provision facilities fit for a future climate? Hotter, drier summers with heatwaves of greater frequency and intensity have serious implications for the UK's ageing population. This report reviews existing evidence and presents primary research in four case study care settings (two residential and two extra care) in England to assess the risks of summertime overheating, and investigate the preparedness of the care settings, both now and in the future.

The report shows that:

- summertime overheating is both a current and future risk in care schemes, yet there is currently little awareness or preparedness at all levels, from designers to frontline staff, to implement suitable and long-term adaptation strategies;
- there is a perception that older people 'feel the cold', but less recognition that heat can also present a significant health risk;
- design for overheating is not commonplace; there is low prioritisation of overheating and future climate change (in briefing and design);
- there is a mismatch between the overheating risks predicted by climate modelling and those measured by empirical monitoring, which underplays present-day risks from high temperatures;
- there is a lack of effective heat management across the case studies due to a number of design and management issues, including lack of investment in appropriate strategies (such as external shading), conflicts between passive cooling strategies and occupant requirements; and
- collaboration among government departments and professional institutions is necessary to harmonise and standardise health-related and building thermal comfort-related overheating thresholds, with particular consideration for care settings.

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Executive summary

Anthropogenic climate change is expected to result in hotter and drier summers, with heatwaves of greater frequency, intensity and duration in the UK. This has serious implications for future heat-related mortality, specifically for older people in care facilities, where research has shown they are among those most vulnerable to the negative health effects of overheating. However, there is a limited evidence base on the thermal performance of care schemes, and on how thermal risks are being managed in practice. This report provides an overview of the key findings of a study that aimed to examine how far existing care homes and other care provision facilities in the UK are fit for a future climate, and to consider the preparedness of the care sector (both care and extra care settings) in light of the consequences of climate change, with a focus on overheating.

More detailed findings for the individual case studies can be found in the accompanying reports available through Oxford Brookes University.

Approach

The research used a case study based, interdisciplinary approach, drawing from building science and social science methods, which included:

- a literature review of existing evidence from both UK and international studies on the climate change-driven overheating risks in the care sector, and the impact of design, institutional contexts, management and staff practices on the risk of summertime overheating, and the thermal comfort and safety of residents during hot weather;
- four case studies (two in residential care and two in extra care schemes) involving:
    - a building survey to identify design features that could contribute to, or support avoidance of, overheating and enable or prevent occupants controlling their thermal environment during periods of hot weather;
    - climate modelling of the current and future overheating risk, and possible physical adaptive measures to reduce the risk in the four schemes, using dynamic thermal simulation;
    - monitoring of environmental conditions to assess current overheating risks and experiences during the summer months (June–September 2015); and
    - interviews with designers, managers, care staff and residents from the four case study buildings, to assess how effectively building design, management and occupant practices address overheating risks and vulnerabilities; and
- secondary analysis of data from a previous research study,[1] to provide supporting evidence.

Case studies

The four case studies are geographically spread across England (one in Yorkshire and the Humber, two in South East England and one in the south-west). Two studies looked at residential care homes and two others at extra care schemes, spanning different building types, construction and age. All but one are managed by not-for-profit organisations. The average age of the residents ranged from 85–89 years old.

Key findings

Care schemes have a culture of warmth: there is a perception that older people are vulnerable to cold, not excessive heat

Throughout the study there was a prevalent perception, from care scheme designers to frontline care staff, that older people 'feel the cold', and that cold represents a bigger threat than heat to older occupants' health. While cold is still more predominant as a health risk, there is less recognition that excessive heat can also present a significant health risk.

Due to this conceptualisation of older occupants, the design, briefing and management of care schemes largely focuses on the provision of warmth, and is reinforced by current regulatory practices; warm environments are prioritised due to their association with good care.

The mismatch between climate modelling at the design stage and empirical monitoring of temperatures in care homes underplays present day risks from high temperatures

Climate change modelling for each of the four case study schemes indicated only limited overheating risks until the 2050s, suggesting that overheating is still only a future risk. However, empirical monitoring data confirm that summertime overheating is a current and prevalent risk that can only worsen if external temperatures are to increase as climate change research indicates.

Monitoring in the summer of 2015 revealed incidences of short-term external heatwaves in two of the case study locations, as well as cases of overheating within several rooms across all four of the case study schemes, even during non-heatwave summer periods.

Overheating risks were more pronounced in one of the south of England case studies, despite this having been built more recently with some consideration of climate change.

Lack of awareness and prioritisation of overheating risks in design and long-term strategic development plans

There was a general lack of awareness of the impacts of overheating, and the prevalence of the overheating risk both now and in the future across all those involved, from designers to frontline care staff and residents. This appears to be, in part, due to the 'warmth culture', as well as a relatively unconcerned attitude, particularly among some asset and strategic managers, towards heatwaves, which are seen as only occurring rarely in the UK, and as such can be managed through short-term adaptation practices such as the use of mobile electric fans.

This issue was reflected in the prioritisation of other design, spatial, cost and care requirements and needs over the possible overheating risk, and a lack of long-term strategic planning for overheating risk mitigation and adaptation. Planning for future overheating was not perceived to be 'top of the agenda' as care and housing providers tend to plan for the near future, rather than the longer term, and they do not anticipate the effects of climate change to be large enough to impact upon operations within the next 30 years or so – the lifespan for which buildings in the care sector are intended to cater.

A lack of standardised overheating criteria and thresholds for thermal comfort and health-related heat risks leads to confusion over the definition of overheating

There is no statutory maximum internal temperature for care schemes. Within health sector guidance, thresholds are generally based on static, external maximum temperatures at which research suggests excess mortality and heat-related illnesses increase (such as 24.5°C in Public Health England's (PHE) guidance, although this varies regionally). In contrast, overheating within the building sector is more specifically related to thermal comfort and indoor temperatures.

Due to this, current overheating assessments in buildings are generally based on the principle that occupants can adapt, and are comfortable with, higher internal temperatures when the external temperature is higher. However, the residents of care homes are likely to be more vulnerable, and the adaptive method may not be stringent enough for such highly sensitive individuals.

While there is some overlap between static threshold temperatures in the building sector guidance (such as in CIBSE Guide A) and the health-related guidance (such as that in PHE's Heatwave Plan), the lack of an evidence base specific to the care sector and older people, and the inconsistency in overheating thresholds, can lead to confusion and a lack of understanding of how to define overheating, and when and where heat-related health risks are occurring. Fundamentally, it prevents the development and implementation of long-term resilience and adaptation strategies to combat both heat-related illness and death, and improve thermal comfort during periods of hot weather in the care sector.

Multiple factors, from design to management and operation of care homes, hinder effective heat management

Care facilities are a hybrid of work and residential (living) spaces. While staff may occupy the building alongside the residents, they are generally more active, creating differences in thermal comfort expectations and tolerance levels of higher temperatures. The study indicated there was a wide range of perceptions of comfort among residents and staff, which can create conflicts in terms of controlling heat and ventilation strategies.

A key finding was that the heating was on throughout the summer months in all of the case study buildings. At all stages, from design and commissioning of new developments to the management and operation of care schemes, there are factors hindering effective heat management. Such issues include:

- **Design for overheating is not commonplace.** In part due to regulatory and cultural notions surrounding the provision of heat in the care sector, innovative design solutions for overheating are not widespread within the design of care schemes. Where they are considered, they are often compromised due to other priorities such as practical, spatial and care requirements, and the tendency in the care sector to design single-aspect rooms lacking through ventilation.
- **Disconnect between designers and end users, and lack of communication from design intent to handover and use of buildings.** Often, due to common procurement methods for new buildings that use a single main contractor to undertake all aspects of the work (who may then appoint several disparate subcontractors), the initial designer of a care scheme is often not involved in the ongoing design and specification process. This can lead to decisions, mainly cost-driven, that conflict with the original design intent for the building. For example, in one of the case studies, the roof design and specification was changed from concrete (high thermal mass that can absorb excess heat within the building) to timber (low thermal mass that cannot absorb excess heat as effectively), without assessing its effect on overheating. Also, insufficient communication of design intent from design teams through contractors and care providers to end users can lead to inadequate user understanding about managing heating and ventilation systems.
- **Lack of investment in long-term strategies.** While all care homes and extra care housing schemes in the study utilised a wide range of measures to deal with the heat, this was often on an *ad hoc* basis. Structural long-term investment in keeping cool was often lacking, and not prioritised. Where overheating was discovered, post-construction 'quick-fix' approaches such as localised mobile air conditioning units and electric fans were used, rather than reviewing long-term strategies such as fitting fixed, external shading devices (shutters or louvres) and using heavyweight construction materials that absorb heat.
- **Separation of roles and lack of clarity over responsibilities for heating management within care organisations.** Complex management structures resulting in the separation of building management and maintenance teams (usually based offsite) from care staff can mean that the responsibility for heating control is removed from the daily users (care staff and residents), and so they are not always able to alter temperatures. It can also mean that understanding of how to manage the heating systems is not communicated to the users. In addition, the care sector often has a high turnover of staff, which can result in further confusion about how the heating and ventilation systems work, and a lack of clarity over whose responsibility they are. In addition, if onsite care staff do not necessarily feel they have responsibility for or permission to alter the heating system, this can lead to contradictory actions, like staff opening windows when the radiators are on.
- **Conflicts between existing passive cooling strategies and resident requirements.** Internal shading (blinds and curtains) are common, but keeping blinds closed during the day as a remedial measure in the heat is feasible only where rooms are unoccupied, as residents need access to daylight. Issues such as health, safety and security can also impede heat risk management, for example the need for window restrictors can limit occupants' ability to open windows to provide adequate ventilation.

- **Differing occupant control and agency.** Often, residents of the residential care homes studied were reliant on care staff to provide thermal comfort due to physical and cognitive frailties. Dependency varies significantly in the extra care setting; in the communal areas, controls were secured and the residents could not alter them, although they were expected to control their own thermal environment within their private rooms. In both settings, particularly in the communal areas, there can be conflict between what the residents desire, and what is best for their health and comfort. This is particularly evident where residents with dementia and other cognitive frailties are present. As dementia is likely to become increasingly common, the balance between providing accessible, user-operable and automated controls is becoming more critical.
- **Engrained practices and habits prevent short-term adaptation.** Care staff and residents' routines can be inflexible, particularly with regard to dressing, showering and provision of hot meals. Such inflexibilities can contribute towards occupants' vulnerability during heatwaves, as engrained routines prevent the uptake of short-term measures to reduce the adverse impacts of high temperatures. Even where managers and carers are aware of this issue, their actions can be constrained by occupants' expectations.

Awareness and application of the PHE Heatwave Plan

All of the care managers interviewed in the present study were aware of the PHE Heatwave Plan, which offers guidance on how to prepare and respond to periods of hot weather, specifically heatwaves. However, most other care staff interviewed were unaware of the Heatwave Plan, although they had an understanding of some of the measures that could be taken in particularly hot weather. This, combined with a lack of visible feedback on actual temperatures (rather than temperatures perceived by the staff), and the reactive rather than proactive approach to heat management evident in the case studies is likely to make the implementation of appropriate measures, at the right time, difficult.

The study corroborated previous findings from Brown (2010) that while the Heatwave Plan seems sensible, practical and comprehensive, the implementation of some of its guidance can be difficult in practice if the advice does not fit in with the everyday social and managerial routines and practices within care schemes, as well as the physical condition and thermal comfort perceptions of some residents. The managers also reported that there were practical difficulties in terms of creating 'cool rooms' due to a lack of suitable rooms, and the issues with moving all occupants (as may be required) into one room.

Recommendations for practice and policy

In becoming more resilient to overheating and heatwave risks, the care sector's aim should be to ensure that no additional ('excess') mortality (death) or morbidity (illness) occurs during future heatwaves. Given that vulnerable residents are within settings that should be providing care and therefore protection against thermal risks – as they already do against cold weather conditions – this is a reasonable aim, and both building design and ongoing management and care practices need to become better focused towards this goal.

This report provides recommendations for practice within the care and building sectors, as well as for policy and regulatory/guidance bodies. While it seeks to outline suggestions for individual bodies, the complex nature of the overheating risk, interactions between climate change mitigation and adaptation measures, as well as the operation of the care sector itself, means that the recommendations often involve multiple parties, and require significant cross-collaboration and communication.

Table 1: Recommendations for policy-makers and practitioners

Recommendation	Key stakeholders
National policy-makers and practitioners	
Challenge the culture of warmth and increase awareness of the current and short-term future risks of climate change and overheating in the care sector; promote best practice in terms of both design and management measures that enable resilience and future adaptation.	DoH; PHE; CQC; care providers; design, commissioning and development teams
National policy-makers	
Develop more detailed national guidance on temperature monitoring for minimising heat risk in the care sector.	DoH, PHE with others
Develop and implement an overheating detection protocol for raising awareness and early identification of the risk of overheating, using smart sensors and surveys during summer months in buildings with vulnerable occupants; promote this in the Heatwave Plan.	DoH; PHE, CQC; and other governmental bodies working in the care sector
Collaborate to harmonise and standardise health-related and building thermal comfort related overheating thresholds, with a particular consideration of care settings.	CIBSE; DCLG; DoH, PHE; DEFRA
CQC should consider preparedness for climate change as a health risk within the care sector, and how its policies and procedures address this risk. Consider integrating criteria on preparedness for current and future overheating and other risks posed by climate change, and the practical implementation of the Heatwave Plan for England into care sector inspection arrangements.	CQC; PHE; DoH
Undertake further research including: monitoring of risks in the care sector in hot weather, to provide evidence on the scale of the problem; when health effects occur, as well as the take up of guidance.	DoH; PHE; CQC
Share insights from case studies where heatwaves have been experienced and tackled with those involved in the design, management and use of care homes.	DoH; PHE; CQC
Practitioners	
Improve resilience and promote awareness of overheating in the care sector by: • monitoring for and minimising overheating risk; • adopting localised heatwave plans that apply PHE's guidance with a series of actions for the local site setting, considering both short-term responses to working practices and longer-term solutions; and • ongoing briefings and training for care managers and staff, to address the management of overheating risk both generally and within their specific setting.	Local authorities; care providers; onsite care managers and staff; PHE
Support communication and greater clarity on the roles and responsibilities of staff in heatwaves, in terms of the operation of heating and ventilation systems in care homes, and other responses needed considering those involved in site management and maintenance, care scheme managers, frontline care staff and residents.	Local authorities; care providers; onsite care managers and staff
Ensure design of care facilities takes climate change impacts into account, e.g. consider issues regarding location and orientation, as well as potential design solutions to avoid future overheating problems.	Design, commissioning and development teams; onsite care managers and staff

Conclusion

This study provides important new evidence on the risks and actual experiences of overheating in both care and extra care facilities, given that there is currently little research on heat management, overheating and thermal comfort in these settings in the UK. Such research is essential if adequate facilities are to be provided for the UK's ageing and vulnerable population.

The findings suggest that overheating is a current risk that is likely to be exacerbated in the future due to climate change, yet there is currently little awareness and implementation of long-term strategies to provide suitable adaptation methods, and increase resilience within the sector. Such strategies require input from designers, care home commissioners and development teams, asset/service managers, onsite managers and care staff, and residents, as well as support such as enhanced and focused regulations, standards and guidance from key care sector bodies and government departments or agencies. Perhaps most urgently, there needs to be a culture change within the care sector itself, so that the health risks posed by excessive heat are prioritised alongside the risks to health from the cold.

1 Introduction

Anthropogenic climate change is expected to result in hotter, drier summers, with heatwaves of greater frequency, intensity and duration (DEFRA, 2011). This has serious implications for future heat-related mortality, specifically for older people in care homes who, research has shown, are among those most vulnerable to the negative health effects of overheating (AECOM, 2012; Lindley *et al.*, 2011). The need to adapt to ongoing climate change has also been highlighted by the Heatwave Plan for England (PHE, 2015a) and the recently published report by the UK's Adaptation Sub-Committee (ASC) on the potential climate change risks to population well-being (CCC ASC, 2014).

This report presents the findings of a 15-month research study funded by the Joseph Rowntree Foundation (JRF). The study aimed to examine how far existing care homes and other care provision facilities in the UK are fit for a future climate, and to consider the preparedness of the care sector (both care and extra care) in light of climate change driven overheating, now and in the future.

The objectives were to:

1. Review existing evidence on the extent to which care provision facilities are fit for a future climate and the impacts of overheating risks.
2. Examine the design, management and use of a range of care settings to:
    a. assess how far the design and management of the built environment enables care residents to deal with the potential impacts of climate change;
    b. explore the extent to which care service providers, including managers and frontline staff, are aware of potential climate change impacts and risks;
    c. examine whether the current behaviour and practices of residents and staff in different settings facilitates resilience; and
    d. identify any measures needed to enhance climate resilience in different care settings, with recommendations for national and local policy and practice.

This chapter lays out the context of the study, and provides a summary of the review of existing literature that underpinned the research, including what the health risks associated with overheating are, who is at risk, and what factors exacerbate these risks within the care sector. Finally, there is an overview of national strategies and current responses to hot weather risks, as well as the standards, guidance and regulations relating to heatwaves and overheating in buildings.

Research context: climate change risks and the care sector

The *UK climate change risk assessment* report (DEFRA, 2012) identified a number of risks posed by climate change that are likely to affect housing in the care and residential care sectors, including impacts on air quality and increased risk of flooding. The most significant risk, though, is posed by heat. Higher than average temperatures and heatwaves are likely to lead to overheating in buildings and increased heat-related mortality and morbidity, and a number of other health-related risks (Hames and Vardoulakis, 2012). The existing literature points to a number of factors that may impact the risks in care settings, including: perceptions of risk; institutional and management practices; the physical environment; and building design.

What are the health risks?

Studies have demonstrated a linear relationship between higher external temperatures and increases in mortality (Armstrong *et al.*, 2011), with PHE (2014) guidance stating that excess heat-related deaths may first become apparent at 24.5°C. The principal causes of illness and death during heatwaves are cardiovascular and respiratory disease (PHE, 2014), in part due to exacerbation of the effects of air pollution on respiratory problems, and also to the direct effect of heat causing additional strain on the heart in circulating blood to the skin to keep cool.

There are a number of other heat-related illnesses, including heat cramps, heat rash, heat oedema, heat syncope and heat exhaustion (for definitions, refer to Glossary). If heat exhaustion is left untreated, it can develop into heatstroke, leading to a failure of the body's temperature control system. Heatstroke can lead to cell, organ and brain damage, and even cause death (PHE, 2014). Higher ambient temperatures and dehydration have also been linked with increased incidence of bloodstream infections (Al-Hasan *et al.*, 2009, cited in PHE, 2014).

While it is possible that external temperature rises from climate change will cause an increase in some individual pathogens in water and food, a report by the UK's Health Protection Agency (Vardoulakis and Heaviside, 2012) suggests that rates of water- and food-borne diseases are unlikely to increase, provided the UK's public health infrastructure is maintained and strengthened. The risks, however, from vector-borne diseases (such as those transmitted by mosquitos) are likely to increase (Vardoulakis and Heaviside, 2012).

What is the scale of the health risks?

It is anticipated that the most direct impact of climate change on health will be in changes to heat-related mortality rates (Hajat *et al.*, 2014). The most recent estimate indicates that there are currently around 2,000 premature heat-related deaths in the UK each year, compared with an estimated 41,000 premature deaths caused by cold weather (CCC ASC, 2014). Heat-related mortality is expected to increase, with one study predicting approximately 7,000 excess heat-related deaths per year in the UK by the 2050s, while cold weather will account for around 40,000 excess deaths annually (CCC ASC, 2014; Hajat *et al.*, 2014).

The heat-related impacts on morbidity (disease patterns) are more difficult to quantify. This is partly because of the limited number of publications on this subject (Hames and Vardoulakis, 2012), and inconsistencies between the findings of different studies (Ye *et al.*, 2012). Another problem is that many people die before the effects of heat-related illness are recognised (Kovats *et al.*, 2004).

Whose health is at risk?

Studies across a wide range of locations and climates (including Spain, Italy, France, the Netherlands, the USA, Australia and the UK) indicate that older people are particularly vulnerable to the effects of excessive heat (Diaz *et al.*, 2002; Conti *et al.*, 2004; Fouillet *et al.*, 2006; Salagnac, 2007; Garssen *et al.*, 2005; Luber and Sanchez, 2006; Guest *et al.*, 1999; PHE, 2014; Åström *et al.*, 2011). This might be because the body's physiological response to heat is impaired with age. During exposure to heat, many older people display a reduced sweat rate, decreased skin blood flow associated with a lower cardiac output, and less redistribution of blood flow from the renal and abdominal organs (Kenny *et al.*, 2010).

The body's capacity to cope with heat is also diminished by chronic or severe illnesses (PHE, 2014), which are more common in the older population relative to the population as a whole (Koppe *et al.*, 2004). Particularly vulnerable to heatwaves are those individuals with heart conditions (Cui and Sinoway, 2014), respiratory disease, renal disorders, diabetes, Parkinson's disease or severe mental illness (PHE, 2014). Obesity can also cause people to be more vulnerable to the effects of heatwaves (Koppe *et al.*, 2004). Certain medications (such as those that affect thermoregulation, the ability to sweat and electrolyte balance) can increase people's vulnerability to the effects of heat (PHE, 2014).

Epidemiological studies conducted in the UK and France indicate that heat-related mortality during heatwaves is highest among occupants of residential and nursing homes (Kovats *et al.*, 2006; Fouillet *et al.*, 2006), despite the presence of care staff who could act to protect vulnerable residents. A German study found an increased heat-related mortality risk among all nursing home residents, regardless of age (Klenk *et al.*, 2010), while during the heatwave experienced in France in 2003, mortality was highest in the least physically frail residents (Holstein *et al.*, 2005). This study helps to explore why this may be the case.

What factors exacerbate the risk?

Studies suggest that a number of factors, in addition to age and health, can affect the vulnerability of older people in care facilities, and therefore exacerbate the health and mortality risks from high temperatures and heatwaves, including:

- personal and social factors, such as people's adaptive capacity, behaviours, practices and perceptions of risk;
- institutional contexts and practices;
- physical environment; and
- building design.

Social behaviours, practices and perceptions

Social practices and behaviours, alongside physiological changes over time, affect people's ability to adapt (acclimatise) to local conditions (PHE, 2014), which can somewhat explain why regions of Europe with hotter summers do not have significantly higher rates of heat-related mortality than areas with cooler summers (Keatinge *et al.*, 2000) – people have acclimatised to prolonged periods of hot weather. While people are able to acclimatise to long-term, gradual changes in temperatures (to a certain level; Parsons, 2003), initial physiological adaptation can take a few days (Kovats and Akhtar, 2008). Difficulties with short-term adaptation could explain why there tends to be a relatively higher number of deaths in the first few days of a heatwave (PHE, 2014).

Older people tend to be more sedentary than younger people; analysis of English House Condition Survey data suggests that people aged over 65 spend more than 80% of their time at home, and people aged over 85 more than 90% (Adams and White, 2006). As such, they are more susceptible to higher temperatures within buildings.

People's perception of the risk is another key factor in their adaptability to extreme weather. Relatively healthy and independent older people have been found to actively dissociate themselves from being labelled 'old', and do not consider themselves vulnerable to hot weather or perceive themselves to be the intended recipients of heatwave warnings, even if they do appreciate the associated risks to 'older' people (Abrahamson *et al.*, 2009). Subsequently they do not generally prepare for extreme weather events (Wolf *et al.*, 2010). Social isolation through living alone, decreasing family and friendship networks, and language barriers can also increase the risk of mortality during extreme weather periods, as well as increasing mental and physical health problems (Islington Council, 2012). This may be particularly relevant in the management of risk in extra care housing schemes, where residents are more independent.

Institutional contexts, management and staff practices

Care and extra care schemes are hybrid building types, slipping between conventional categories of home and work, and public and private space, and are subject to relatively specific institutional, regulatory and management regimes (Walker *et al.*, 2015). While extra care and care (nursing and residential homes) vary significantly in terms of spatial requirements, dependency and autonomy of occupants (see Box 1), in both settings existing research has shown that warm temperatures are generally viewed as positive and cold as very negative. Thus achieving thermal comfort is strongly related to keeping residents warm (Brown, 2010; Walker *et al.*, 2015; Neven *et al.*, 2015; Lewis, 2015). Care homes, where residents are generally more frail, both physically and cognitively, than residents of extra care schemes, are typically heated to a relatively high level; the heating is often on 24 hours a day, 7 days a week, all year round, with heating systems designed in such a way that if a (part of) the system fails, a back-up system takes over (Walker *et al.*, 2015; Neven *et al.*, 2015). Extra care schemes can also exhibit these characteristics, but less uniformly.

Box 1: Care and extra care settings

Table 2: Care and extra care settings

Care home	Extra care facilities
A residential setting where a number of older people live, usually in single rooms, and have access to onsite care services, with meals provided and staff on call 24 hours a day. Designed to accommodate older people who have physical and/or mental frailties and are more reliant on others. A home registered as a 'residential care home' will provide personal care only – help with washing, dressing and taking medication. A home registered as a 'care home with nursing' provides personal care as well as having a qualified nurse on duty 24 hours a day. Such a home is likely to house more frail residents in poorer health, with lower levels of independence than those in a residential home. Some care homes are registered to meet a specific care need, for example dementia or terminal illness (EAC, 2015). Care homes are usually designed in a way that has some similarity to hotels: with private bedrooms and wash facilities (ranging from simple wash basin to complete en-suite facilities), and communal lounge and dining areas.	Extra care housing is also known as 'very sheltered housing', 'assisted living' or 'housing with care'. Designed to accommodate older people who are becoming more frail and less able to do things for themselves, but who still require and/or desire some level of independence. Extra care housing schemes provide varying levels of care and support, but at a minimum there will be some kind of on-call emergency assistance. Extra care housing schemes can be provided in a variety of built forms, including blocks of flats, bungalow estates and retirement villages. They generally consist of 20–50 self-contained units (with kitchen, living/dining, bathroom and bedroom/s), with similar communal facilities to care homes (dining and lounge areas), as well as laundry facilities. Extra care also often includes health and fitness facilities and hobby/computer rooms, and even doctors' surgeries.
Both care home and extra care housing schemes are usually restricted to people over the age of 55 (SCIE, n.d.), although care homes will base their decisions more on a needs-related basis.	

The relative status of warmth is further reinforced by two institutional aspects: the regulatory context and business considerations. Neven *et al.* (2015) describe the degree of scrutiny and regulation that care homes are under, and emphasise that the temperature and thermal comfort of the home are part of this, with Care Quality Commission (CQC) inspectors checking room temperatures and scrutinising staff responsiveness to complaints from residents about being cold. Furthermore, many care homes are run as businesses, and their success relies heavily on keeping occupancy rates high; being labelled as a care home that is too cold can be very damaging, as this is quickly associated with poor care standards (Neven *et al.*, 2015). Thus the notion of older people as people who feel the cold, regulatory regimes and business reputation considerations all mutually reinforce the idea that care homes should be warm places.

Research by Brown (2010) into care schemes, specifically, outlined five institutional aspects that can limit management of and responsiveness to heatwave risks:

- The material infrastructure of care homes can unintentionally make it hard to keep the home cool. For example, the care homes visited by Brown had an evident need for ventilation by opening windows, but the employment of window limiters, in themselves a safety feature, greatly restricted the amount of ventilation that could be achieved.
- Hierarchical power (particularly social) structures can prevent junior staff and residents from interacting with the heating and cooling systems, and controlling their own thermal environment. An example of this in Brown (2010) was of residents being afraid to ask for assistance in adjusting their clothing for fear of being negatively labelled a 'nuisance' by the care staff.

- Carers, care home management and inspectors alike have a particular view of indoor temperatures, with the cold seen as problematic and dangerous. When hot weather arrives, measures employed during cooler temperatures to maintain a high indoor temperature are often not changed, which in turn contributes to even higher indoor temperatures, and therefore the increased vulnerability of the residents.
- Actively preventing residents in care homes from moving around, mainly for control and safety purposes, can result in a lack of resident mobility, which in turn is mutually reinforced by high temperatures. A lack of mobility leads to inactivity, which leads to a drop in body temperature. This is combated by turning up the heating, which subsequently leads to an increase in body temperature, making residents drowsy and even more immobile. Thus a vicious cycle is created.
- The timetable of the care home and the routines it generates can introduce inertia and inflexibility, which may make adapting to the needs generated by hot weather difficult. An example of this is hot meals and drinks still being served during periods of hot weather, and at the same time as usual, irrespective of whether that could contribute to people feeling hot. By contrast, a lack of regular consideration of heat management practices can lead to an uncoordinated approach to altering heating controls, which may be driven by individual complaints and not a more proactive routine response to changes in external temperatures.

Physical environmental factors

Environmental factors such as physical and geographical location can also affect people's vulnerability to heatwaves (PHE, 2014). A physical risk factor in terms of excess heat-related deaths is the urban heat island effect, where hard surfaces and the presence of heat sources cause urban areas to have a higher air temperature than rural areas (Harlan *et al.*, 2013). There are also regional variations in the average external temperature thresholds (from around 17°C in North East England to 20°C in London) at which populations in the UK begin to show heat-related mortality (CCC ASC, 2014). These relatively low thresholds demonstrate that mortality from heat is sensitive to differences in mean temperatures, as well as the intensity and frequency of heatwaves, and a significant proportion of heat-related mortality occurs outside of recognised heatwave events (AECOM, 2012).

Building design

Building design is also a key factor affecting people's vulnerability to heat, as it can determine the thermal response of buildings to higher external temperatures (Gupta and Gregg, 2012; 2013). There is evidence that new-build care and extra care housing schemes are already too warm for occupants and are 'overheating' (Burns, 2008; Barnes *et al.*, 2012; Lewis, 2014; Guerra-Santin and Tweed, 2013). This problem is exacerbated by many new buildings having high levels of thermal insulation and airtightness to minimise heat loss, which can prevent the dissipation of unwanted heat, particularly in summer (Zero Carbon Hub, 2014; NHBC Foundation, 2012). This problem will become more prevalent if energy efficiency agendas are pursued to support climate change mitigation without due regard to the risks of heat and need for ventilation. Rises in external temperature are likely to lead to even more overheating in buildings (DEFRA, 2012).

Care and extra care housing schemes are generally hybrid building types, simultaneously functioning as long-term residences, sometimes nursing environments, and workplaces (Walker *et al.*, 2015). This hybridity is reflected in the design of care and extra care buildings, and there are many other aspects that can impact (positively and negatively) on the building's risk of summertime overheating. These include safety issues, diverging needs and preferences (particularly between staff and residents), user-technology interaction, and questions about who is responsible for thermal conditions (van Hoof *et al.*, 2010).

To date, consideration of the possible effects on care sector buildings of climate change, particularly rising temperatures, has been limited; the key studies are those funded by the Technology Strategy Board (TSB, now Innovate UK) under the programme *Design for Future Climate: adapting buildings (D4FC)* (Gething and Puckett, 2013; Gale *et al.*, 2011; McHugh and Keefe, 2012) and JRF's *Designing Red Lodge for a future climate* (PRP, 2014).

Findings from the D4FC and JRF studies reflect the wider findings of literature with regard to how the design of buildings affects the risk of overheating, both in minimising heat gain and supporting excess heat loss.

Design can **minimise heat gain** by addressing both internal heat gains (including body heat from occupants, electrical appliances, and hot water and heating pipework) and solar gain (amount of heat from sunlight entering the building; see Figure 1). A balance must be struck to ensure adequate, but not excessive, sunlight entering the building, as sunlight is important for health and well-being, particularly for people who are largely house-bound (Tregenza and Wilson, 2011), but excess solar gain may be a problem for overheating.

Figure 1: Minimising heat gain through use of external fixed shading (brise-soleil)

Maximising excess heat loss can be achieved through appropriate design and ventilation strategies. Buildings constructed with high-density materials, such as concrete, bricks and tiles, benefit from high thermal mass (the ability of materials to absorb and store heat energy), which can help to even out internal temperatures. Heat is absorbed into the walls, floors and ceilings of the building during the day (cooling the air internally) and – provided there is a means by which heat can be removed overnight – can then help release the heat slowly and keep the building cool (Gething and Puckett, 2013). Where buildings are not well ventilated, high thermal mass can cause heat to be retained for longer than it would otherwise be. Natural ventilation strategies (opening windows and/or trickle vents) are common, however concerns over health and safety, noise pollution, fear of intruders and preventing insects from entering the home, may well encourage an increase in the use of mechanical ventilation systems. However, these systems require occupants to operate the building in a manner unfamiliar to many people in the UK, and automatic window closing/opening could be unsettling for people with dementia (Gething and Puckett, 2013).

Defining and understanding heatwaves and the risk of overheating

There is a lack of clear definition of 'heatwaves' and 'overheating' (Zero Carbon Hub, 2015; CIBSE, 2013). This is in part linked to the complexities of assessing individuals' adaptability to external temperatures, depending upon the climatic conditions they face and are used to, as well as assessing thermal comfort, which is very subjective (see Box 2). There are no specific regulatory compliance requirements to address overheating in the care (or wider housing) sector.

Box 2: What are overheating and thermal comfort?

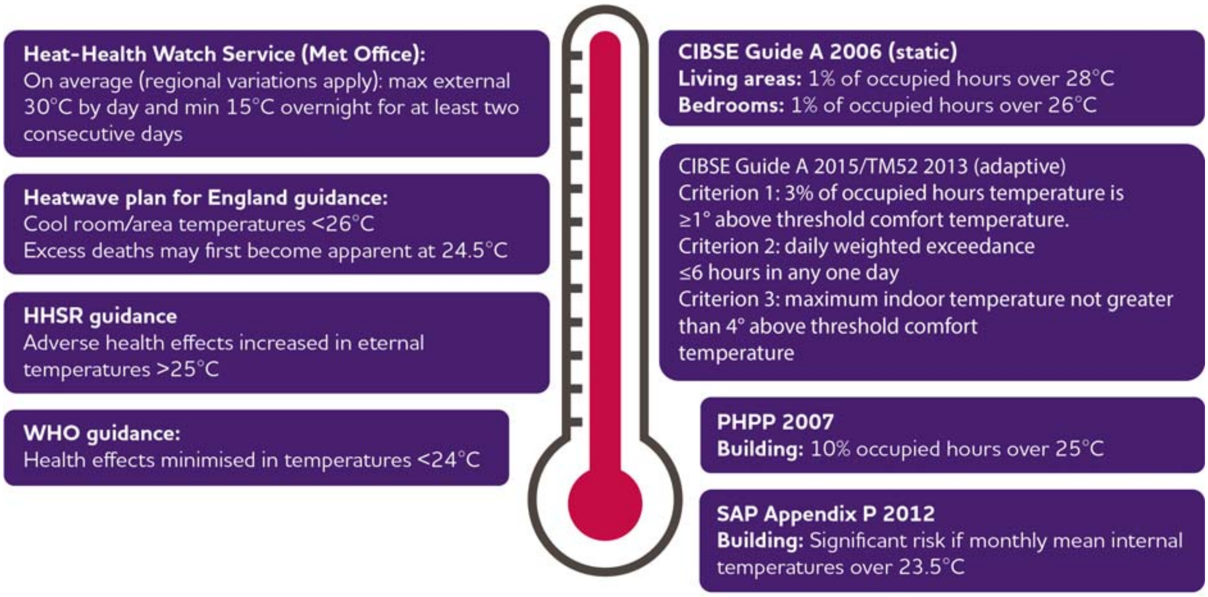
To 'overheat' is to make or become too hot. Overheating is closely linked to 'thermal comfort'. Thermal comfort is defined in BS EN ISO 7730 (2005) as 'that condition of mind which expresses satisfaction with the thermal environment'. In other words, this is when someone is feeling neither too hot nor too cold. Such a condition is highly subjective, and people have very different preferences in terms of their personal thermal environment.

Thermal comfort is not just reliant on the surrounding air temperature; the factors influencing thermal comfort are wide and varied, but include personal and environmental factors such as air temperature, air velocity, relative humidity, uniformity of temperature, clothing, activities, and the physical and mental attributes of the person. While it is impossible to specify a thermal environment that will be satisfactory to everyone, it is possible to specify environmental conditions (generally a temperature range or band) that are acceptable to the majority of people. The Health & Safety Executive suggests that 'reasonable comfort' is achieved when at least 80% of occupants express thermal comfort.

Thermal discomfort is a sign that the mechanisms in place for people to remain comfortable are inadequate. While thermal discomfort itself is not a sign of ill health effects, the thermal environment in which it happens can signify a potential increase in health risks, particularly if high temperatures are reached; the DCLG's Housing Health and Safety Rating System (HHSRS) states 'mortality increases in temperatures over 25°C' (DCLG, 2006) and the Heatwave Plan for England guidance (PHE, 2015b) states that a 'cool room' maintained at a temperature below 26°C should be provided due to the increased health risks above this temperature.

Guidance within the health and building sectors on threshold temperatures for overheating and heat-related risks varies (Figure 2). Within the health sector, guidance focuses on external temperature thresholds above which heat-related health risks begin to occur. Examples of this include the DCLG's HHSRS and the PHE Heatwave Plan guidance based on the Met Office's Heat-Health Watch Service (HHWS). The HHWS accounts for regional variations in external threshold temperatures (average threshold temperatures are 30°C during the day and 15°C overnight for at least two consecutive days), despite these temperatures being above threshold temperatures at which research suggests excess heat-related mortality can begin to occur.

Figure 2: Key health and building sector standards and guidance relating to overheating and heatwave risks



Within the building sector, methods of assessing overheating relate mainly to thermal comfort, rather than specific health risks. Furthermore, until recently, many of these standards were based on fixed metrics, such as the Chartered Institute of Building Services Engineers (CIBSE) recommendation that bedroom temperatures should not rise above 26°C for more than 1% of occupied hours. Increasingly, however, thermal comfort standards are based on adaptive thermal comfort models, which assume that comfortable indoor temperatures increase as external temperatures rise. These dynamic models make it more feasible for naturally ventilated buildings to comply with established thermal comfort standards (CCC ASC, 2014) and appear appropriate given that, to some degree, people adapt to higher temperatures both physiologically and in their behavioural and social practices (Dengel and Swainson, 2012). However, as the evidence outlined above suggests, residents of care and extra care schemes may be less able to adapt to higher temperatures, and further research into both the type (adaptive or static) and appropriate criteria for health-related indoor temperature thresholds is required, to enable the development of appropriate health-based indoor temperature standards in the care sector.

National strategies and responses to hot weather risks

Since the summer 2003 heatwave in the UK there has been considerable attention in policy circles and elsewhere to the ways in which care and extra care schemes need to prepare for and respond to hot weather. Among other things, this has culminated in the Heatwave Plan for England (PHE, 2015a). This provides specific advice for certain settings or professionals, like care homes (PHE, 2015b) or health and social care professionals (PHE, 2015c). The Heatwave Plan is linked to the UK Met Office's HHWS, which provides early warning of periods of high temperatures that may affect the health of the UK public. The Heatwave Plan explains the effects of heat on the human body with a specific focus on heat-related illnesses; details the risks of hot weather to older people and people who live with chronic and severe illnesses; and provides practical advice on what should be done to prepare for and deal with hot weather. This practical advice is broken up into actions to be performed during several stages. These stages are: long-term planning prior to any hot weather (level 0 – all year round); preparedness for summer (level 1 – June-September); alertness and readiness if there is a 60% chance of at least two consecutive days of hot weather within two to three days (level 2); actions to be taken during hot weather when the threshold temperature has been reached (level 3); and actions to be taken in a national emergency (level 4) (PHE, 2015b). Although small-scale studies indicate there is a need to raise awareness of the Heatwave Plan among relevant stakeholders, to build longer-term preparedness (AEA, 2011), there have been no detailed studies on the implementation and impacts of the Heatwave Plan and its associated guidance.

Summary

Research has shown that, in the UK, awareness of thermal risks and vulnerabilities in older age is focused far more on the cold than on heat; 'biological' and 'institutional' notions of age and ageing have long prioritised the risks of the cold (Day and Hitchings, 2011). Similar considerations, reinforced by regulatory drivers, have informed ongoing practices in the management of care homes so that keeping residents warm is seen as integral to the provision of care (Walker *et al.*, 2015). While there is now a national Heatwave Plan and specific guidance for the health and care sectors on how to respond to heatwave conditions (PHE, 2015a), it is unclear how effective that guidance has been in changing awareness of, preparedness for or practice during heatwaves, in the short or longer term.

This lack of balance between managing risks from heat and cold is also seen in the challenges of building design, where improving thermal efficiency to reduce heating needs in the winter, in compliance with carbon reduction policies, has generated new problems of buildings overheating in the summer (NHBC, 2012; DEFRA, 2012). Given climate change mitigation objectives, it is important that the response to overheating and heatwave risks does not automatically take the form of increased use of air conditioning, as it has in some care settings (Walker *et al.*, 2014). Hence there is a need for an integrated approach to manage the thermal system in care settings in an effective, climate-sensitive and sustainable way, to both address risks from increasing high temperatures due to climate change, and also to avoid further contributing to carbon emissions.

Currently, there is no standard definition of overheating; in the building sector it is closely aligned with thermal comfort, rather than specifically being health-related. The limitation of this is that design is being guided by comfort requirements rather than focusing on the health impacts of design and subsequent management responses.

In the care and health sectors, there is also little guidance or clear regulation in terms of appropriate threshold indoor temperatures and thermal environments, in part due to a lack of research and a concentration in current research upon the effects of external (instead of internal) temperatures on health. It is also partly due to a lack of data; large-scale epidemiological studies use external temperatures from meteorological data, but there is no similar record of internal temperatures for UK buildings.

The challenges laid out here raise questions about how overheating can be effectively managed in the care sector. These issues are considered by examining the overheating risks and experiences of high temperatures in four different care settings in England.

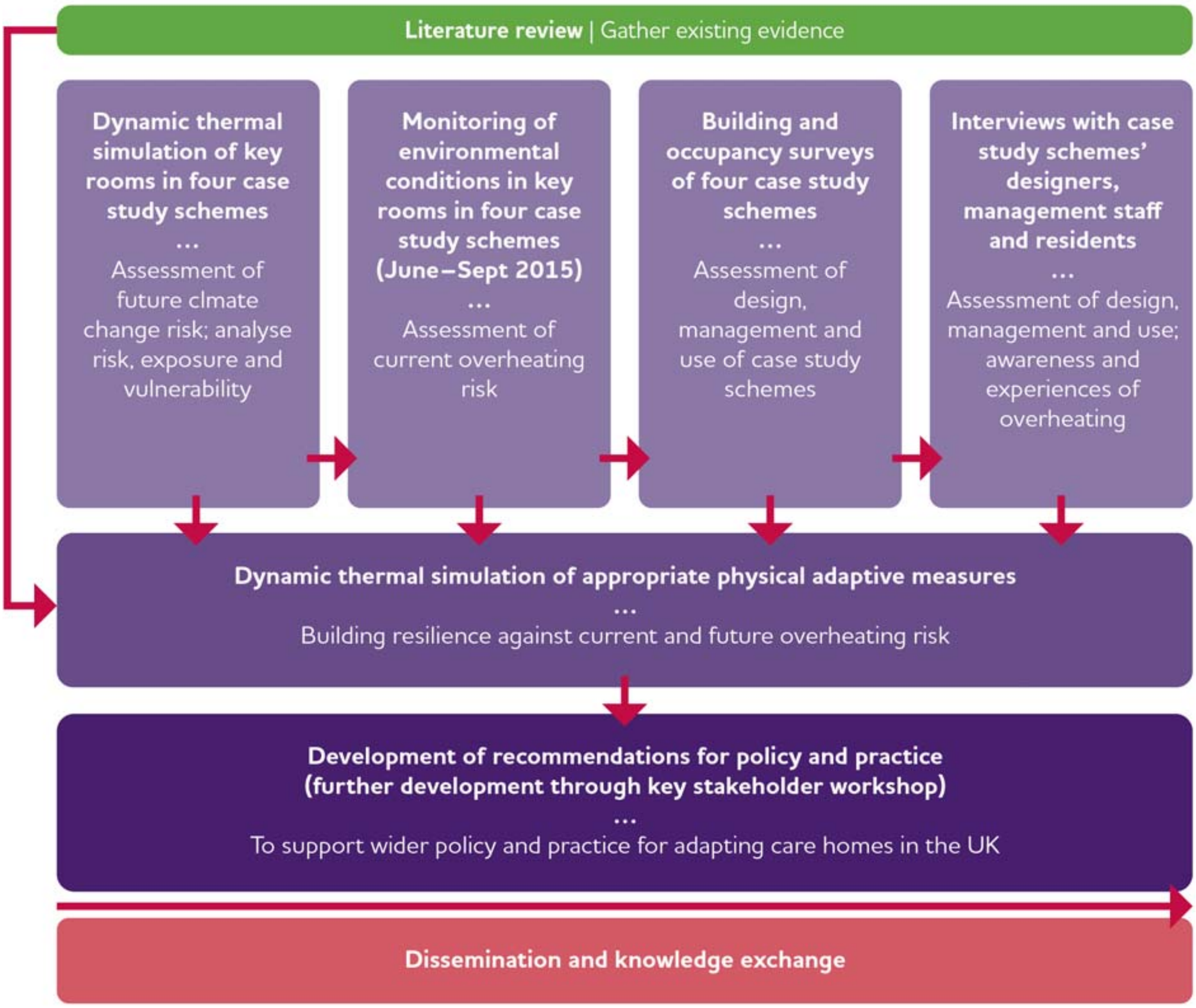
2 Research study

This chapter outlines the aims, objectives and methodological approach adopted in the research study to understand the risks and preparedness for overheating of different care schemes, by examining the issues in four settings (two residential care homes and two extra care facilities). An overview of the case studies is provided, and the overheating metrics used in the analysis of the quantitative data collected are described.

Methodological approach

The methodological approach (Figure 3) was case study based, sociotechnical and interdisciplinary, drawing from building science and social science methods.

Figure 3: Methodological approach of the research study



Physical building and occupancy surveys

Surveys were undertaken by the researchers to identify building design features (see Chapter 3) that might contribute to the avoidance of overheating and enable or prevent occupants (with differing levels of physical and cognitive ability) to control their thermal environment during periods of hot weather. Detailed reviews of plans, specifications, and construction and technical details of the case study buildings were also carried out to inform the climate change risk modelling.

Modelling and dynamic thermal simulation

This was used to provide a design review of climate change risk (see Chapter 4), to understand the overheating risks posed by climate change for four individual case study schemes and the implications for the wider care sector industry. In addition, dynamic thermal simulation was used to appraise robust, technically feasible and acceptable (physical) remedial options for building resilience across different care settings (see Chapter 7). Uncertainties and limitations in modelling included: assumptions made about detailed occupancy and use patterns; in some cases, due to lack of detailed construction drawings, assumptions about building fabric were based on the age of the building; and weather files used in the modelling study represent average weather, although new weather files from CIBSE have been recently released for 14 locations (CIBSE, 2016).

Monitoring of the internal and external environmental conditions

Monitoring was also undertaken in the four case studies in order to assess current overheating risks (see Chapter 5). The data loggers installed included temperature and relative humidity sensors (Tempcon HOBOs and Maxim iButtons®) as well as CO_2 level sensors (Gemini Tinytags). Across the four case studies, 33 rooms were monitored, wherein 49 data loggers were installed. There were gaps in the data, most likely due to the removal or unplugging of the loggers by staff or inquisitive residents, as well as faults with the data loggers themselves. The data loggers were installed in early June, except in case study D where they were installed in early July 2015, due to late selection. The loggers were removed in early October to provide at least three full months of data where possible.

Semi-structured interviews

Interviews were conducted to assess how building design, management and occupant practices address overheating risks and vulnerabilities, and to explore any direct experiences of managing overheating in practice (see Chapter 6). For each case study, the aim was to interview the designers and asset/strategic managers, as well as those working and living in the buildings (including residents, carers, administrative staff and building maintenance workers). In total, 30 interviews (conducted with 32 respondents) were undertaken during September 2015 with five designers/architects, four asset managers (an overall managing director, a sustainability manager, a development director and a head of specialist and sheltered housing), four care scheme managers, seven carers, two building maintenance staff and ten residents. In addition, secondary analysis of data from the *Conditioning demand: older people, diversity and thermal experience* study was undertaken, reanalysing transcripts of semi-structured interviews with: care home owners, managers, carers, residents and maintenance persons (27 individuals in total), in five extra care housing schemes across England and Wales; and owners, managers, carers, residents and maintenance persons (36 individuals in total), in six care homes (nursing and residential) across Great Britain.

Case studies

The four case study schemes were selected based on the following core criteria:

- an even distribution of care and extra care facilities (see Box 1);
- a mix of homes owned by public and private care providers;
- variation in built age (and related building regulatory context); and
- variation in location (Figure 4).

In addition, as the project was funded by JRF, at least one Joseph Rowntree Housing Trust (JRHT) care/extra care home was selected.

Figure 4: Locations of four case study buildings

Case study recruitment was difficult due to the lack of availability of sufficient information, as well schemes simply being unable to provide adequate time and access. It also must be noted that because of this, the case studies were relatively self-selecting, which may mean that they have some degree of pre-existing interest in questions of overheating and climate change. Table 3 outlines the core criteria for the case studies, and other important characteristics considered during the selection process. More detailed findings for the individual case studies can be found in accompanying overheating case study reports, available through Oxford Brookes University.

Table 3: Case study characteristics

Category	Case study A[1]	Case study B	Case study C	Case study D
Region	Yorkshire and the Humber	South East England	South West England	South East England
Location	Suburban	Rural	Suburban	Suburban
Type of facility	Integrated care community – residential care home with extra care facilities (purpose built)	Residential care home (renovated)	Extra care (purpose built)	Extra care (purpose built)
Ownership	Not-for-profit registered social landlord	Private company	Not-for-profit registered social landlord	Not-for-profit registered social landlord
Gross internal area (m^2)	Not provided	820 (estimated)	4,823	5,500 (estimated)
Number of beds/ dwellings	42 beds + 10 two-bed cottages	22 beds	50 flats	60 flats
Number of occupants	39	22	52	63
Average age of residents	89	87	86	85
Percentage of residents over 85 years	77% (30)	64% (14)	83% (approximately 43)	80%
Age of facility (building regulations year)	2005 (2000)	Pre-1900s (N/A)	2006 (2002)	2012 (2006)
Construction type	Brick/stone and block insulated cavity; concrete beam and block floors	Solid brick; timber floors	Brick and block insulated cavity/ rendered insulation with block; concrete beam and block floors	Steel frame with insulated brick/render wall finish; reinforced concrete slab floors
Ventilation and/or cooling scheme	Mixed mode: natural ventilation with MVHR[2] in residential and communal kitchen and sanitary areas	Natural ventilation with some extract ventilation in communal kitchen and sanitary areas	Mixed mode: natural ventilation with some extract ventilation in residential, communal kitchen and sanitary areas, and air conditioning in lounge and dining room	Mixed mode: natural ventilation with MVHR in residential, communal kitchen and sanitary areas, and air conditioning in office
Single or multi-aspect bedrooms	Single	Single	Single	Single
Exceptional design standards or certification	N/A	Listed building (Grade II)	CSH/EcoHomes Good	BREAAM Excellent

Notes:
[1] Only the care home building was monitored in this study.
[2] MVHR = mechanical ventilation and heat recovery systems

Overheating, thermal comfort and health thresholds

The assessment of overheating is closely aligned with thermal comfort (see Box 2). The majority of the rooms within the case study buildings modelled and monitored were naturally ventilated, although one office (case study D) and one communal lounge (case study C) had air conditioning units, and case study A had mechanical ventilation with heat recovery units installed in most residential areas. The hybrid building type of the case study buildings also means that they comprised domestic (residents' private rooms), non-domestic (offices) and dual-type (domestic and non-domestic) areas, such as the communal living areas that are likely to be used and occupied by residents and staff relatively equally.

There are several methodologies and overheating metrics used to assess buildings (domestic and non-domestic; air-conditioned and non air-conditioned) in England and Wales. The main metrics used to assess the thermal comfort and overheating risk in the case studies were:

- CIBSE Guide A (2006) static overheating and thermal comfort bands, (referred to later as the **static method**;
- the adaptive overheating and thermal comfort method as outlined in BS EN 15251:2007, CIBSE (2013) and CIBSE Guide A (2015), referred to later as the **adaptive method**; and
- the PHE Heatwave Plan for England guidance on heatwaves and indoor temperatures.

The static method enables simple calculations to be undertaken when assessing the performance of a building, as it is based on fixed maximum temperatures and criteria (Table 4), specific to room types (such as 26°C in bedrooms). However, this does not account for occupants' adaptation to their environmental context, including external temperatures.

The adaptive approach was developed by Humphreys and Nicol (1998) through field studies, and is particularly relevant to free-running buildings (buildings not consuming energy through heating or cooling).

Table 4: General summer indoor comfort temperatures (air-conditioned and non air-conditioned rooms) and static method overheating criteria (CIBSE, 2006)

Building/room type	Summer comfort temperatures (°C)[1]	Benchmark summer peak temperature (°C)	Overheating criteria
Non-air conditioned (Table 1.7, CIBSE, 2006)			
Offices Living areas (dwellings)	25	28	1% annual occupied hours over operative temperature of 28°C
Bedrooms (dwellings)	23	26	1% annual occupied hours over operative temperature of 26°C
Air-conditioned (Table 1.5, CIBSE, 2006)[2]			
Offices	22–24	–	–
Living areas (dwellings)	23–25	–	–
Bedrooms (dwellings)	23–25	–	–

Notes:
[1] Generally temperatures within ±3° are acceptable in terms of the thermal comfort response of sedentary persons. However, the updated Guide A (2015) states that, 'a variation of ±2° would be noticed and might cause some complaint at the extremes'.
[2] Higher temperatures may be acceptable if full air conditioning is not present.

Despite the adaptive approach having significant benefits in terms of assessment of thermal comfort and overheating risk, it was developed from research in non-domestic settings and there is still insufficient data to provide similar adaptive guidance for dwellings and hybrid building types such as those required in care schemes. Furthermore, while the adaptive method does enable the sensitivities of occupants to be considered, little research has been done in this field in the care sector. Understanding the sensitivity of people to environmental conditions is particularly pertinent when studying the care sector context, where the residents may be relatively sensitive due to health issues; and there are conflicts between control and health, safety and security evident in this study, and others (PHE, 2014). In addition, despite a focus on the need to use the adaptive method when assessing overheating risk, the current CIBSE Guide A (2015) states:

> Available field study data for the UK [...] show that thermal discomfort and quality of sleep begin to decrease if the bedroom temperature rises much above 24°C. At this temperature just a sheet is used for cover. It is desirable that bedroom temperatures at night should not exceed 26°C unless there is some means to create air movement in the space, e.g. ceiling fans.

A key limitation of the static and adaptive methods is that both are based on thermal comfort rather than the health-related risks of higher temperatures. As such, it was felt appropriate to also review the data in relation to the more health-risk focused guidance contained in the PHE's Heatwave Plan guidance, which advises that certain areas within a care home should be retained at a maximum of 26°C in order to provide 'cool areas' for residents during periods of hot weather (for further detail, refer to Chapter 1, National strategies and responses to hot weather risks).

Summary

The overall methodological approach was case study based and interdisciplinary, using sociotechnical tools including dynamic thermal simulation; building and occupant surveys; monitoring of indoor environmental conditions; and semi-structured interviews with relevant stakeholders, to collect primary data from four case study care schemes. The study also draws from secondary analysis of interview data collected from six care home schemes and five extra care housing schemes.

The four case studies that formed the basis of this study included two care homes and two extra care homes. Three are owned and managed by not-for-profit registered social landlords. The case studies are located across England (one in Yorkshire and the Humber, one in South West England and two in South East England).

A range of overheating metrics have been used within the study for simulation and measurement of actual temperatures, in order to identify current and future overheating risks in the four case studies; mainly the static and adaptive methods, and PHE's Heatwave Plan guidance on threshold temperatures. The variety of methods used reflects the present situation in terms of defining and standardising overheating, particularly in relation to health risks.

3 Building design and overheating

Design and local environmental context characteristics can either ameliorate or exacerbate the impact of climate change and alter the risk of overheating in a locality. Such characteristics include:

- local environmental characteristics of the site, e.g. region, proximity to the coast, elevation, urban density and surrounding building types;
- landscaping, e.g. trees and green space;
- building orientation and internal layout;
- construction type and materials; and
- physical attributes of the building, e.g. height, passive design measures, and heating, ventilation and cooling controls.

This chapter sets out the findings from the building surveys of the four case study schemes. It outlines the influence of local environmental characteristics and design, as well as management and control features. The institutional, personal and social contexts, such as residents' health, degree of independence and agency, as well as the routines and behaviours of occupants, also impact upon management and control within the buildings. Further consideration of this is given in Chapter 6.

Local environmental characteristics of the case study buildings

These characteristics cannot be altered easily and so appropriate building design features should aim to reduce the impacts of climate change and overheating risk. Table 5 outlines the local environmental characteristics of the four case studies, and provides a qualitative assessment of their impacts on the overheating risk.

Of the three case study buildings that are within a suburban context, one (case study C) is situated at the rear of residential properties, which ensures that the surrounding environment has significant green coverage that is likely to help reduce localised temperature increases and heat gain. In contrast, case studies A and D are also in suburban areas, but with significantly less 'soft' landscaping adjacent, which can increase the risk of the urban heat island effect. While case study A is at a higher elevation than the others, and therefore more susceptible to higher temperatures and precipitation increases, case study C is the closest to the coast and is more susceptible to frequency and intensity of storms.

Table 5: Assessment of the local environmental characteristics of the case study buildings and their potential impact on contributing to the overheating risk

Features and hazard relevance	Case study A	Case study B	Case study C	Case study D	Issues raised/best practice examples
Local environmental characteristics					
Region Latitude/longitude affects weather conditions; the south of England is predicted to suffer from greater increases in heatwaves and high average temperatures.	+	–	–	–	– Case studies B, C and D are all in the south of England.
Proximity to coast Proximity to coast affects weather. Coasts are also subject to sea level rise, erosion, and changes in the frequency and intensity of storms.	o	o	+	o	– Case study C is within ten miles of the coast, which could be beneficial due to lower temperatures (sea breezes).
Elevation Higher elevations may show higher temperature increases and greater precipitation increases (Edina, 2015).	o	o	o	o	– Case study A is on relatively higher ground, but the difference is likely to be negligible.
Flood risk Flooding is projected to be exacerbated by climate change (CCC ASC, 2014).	+	+	+	+	+ No case studies are in a flood risk area.
Surrounding urban cover Hard surfaces (e.g. asphalt, concrete and buildings) and limited green cover can lead to the urban heat island effect.	–	+	+	–	– Case studies A and D are in suburban areas with hard surface roads on all four sides of the sites. + Case study C's site, although in a suburban area, is situated at the rear of residential properties and is surrounded by gardens (green cover).
Surrounding green cover Hard urban materials retain heat, and transpiration cooling is limited where there is little vegetation.	–	+	+	–	

Notes: **+** symbolises a positive feature that is likely to contribute to reducing the overheating risk; **–** symbolises a negative aspect that is likely to exacerbate the overheating risk; **o** symbolises an aspect that has a relatively neutral/negligible impact on the overheating risk.

Building design features

The case study buildings included a number of design features that could impact upon the risk of overheating within them, both negatively and positively, as detailed in Table 6 below. Of particular note in terms of good practice, all case studies had well designed soft landscaping within the site boundaries (Figure 5), which can provide cooler microclimates. The balconies in case study D also provide further space for planting and green vegetation in a suburban context (Figure 6). There are examples of good use of external shading measures such as brise-soleil and large overhanging eaves in case study C (Figure 7), fixed vertical panels and wide balconies in case study D (Figure 8) and balconies in case study A. Furthermore, the case studies generally had opening windows or doors at the end of residential corridors, which increase potential for cross-ventilation and air circulation in the communal areas (Figure 9).

Figure 5: Secure walled garden in case study B, with formal lawns and mature trees to provide shade and vegetation

Figure 6: Built-in planters on balconies provide additional vegetation to assist with cooling

Figure 7: External shading features on south-facing façade of case study C

Figure 8: Deep balconies in case study D provide additional shading to rooms below

Figure 9: Corridors with large opening windows provide cross-ventilation throughout communal spaces (as well as for flats/bedrooms)

However, there were also some features that could exacerbate the risk of overheating, including single-aspect residential areas, which can limit the potential for cross-ventilation. Spatial and cost requirements of care home and extra care buildings make dual-aspect residential spaces difficult, although not impossible, to implement. Both case studies A and D have opening windows in corridors adjacent to residential areas. While this does enable cross-ventilation to happen, it relies on the residents leaving their doors open, which can have security and privacy implications. Innovative design solutions can provide alternative passive ventilation however, such as stack ventilation – a method that uses differences in air pressure between different heights to move cool air through the building vertically (like a chimney).

Lighting, appliances and other electrical goods can also contribute to the internal heat gains of a building. In general, the installed fixed lighting is part of the overall design of the building, and in the extra care schemes (case studies C and D), the appliances within the residential units were believed to have been supplied and installed by the contractors. Their contribution to the internal heat gains can be controlled through low energy design and specification (as was the case in the three 'new' case study schemes, A, C and D). However, observations indicated that additional heat gains were likely from lamps brought in by the residents that were not necessarily low energy, and the use of ICT equipment in relatively cramped office spaces (particularly case study A).

In addition, all case studies had centralised heating and hot water systems that ran 24/7, throughout the year. Where it was possible to review, often the route of the distribution pipes followed corridors and, unless adequately insulated, could be contributing significantly to internal heat gains throughout the building.

Design of controls: enabling occupant management of thermal environment

The design of controls can either enable or constrain the ability of the occupants to manage their thermal environment. As Table 6 demonstrates, there was a mix in terms of both positive and negative aspects to the installed controls. It also became apparent that as much as the design affected the ability of the occupants to effectively manage their thermal environment, the variety, agency and capacity of the occupants themselves also played a significant role. It was observed that in all case studies, there was conflict in terms of the use of controls in the communal areas; for example, in case study B (residential care home), radiators in the residential and communal areas have covers on them (Figure 10) and in case study D (extra care scheme), the managers had to install locked cases over the thermostats in the communal areas to prevent 'tweaking' by residents. Furthermore, it was reported (although not confirmed) that in case study C (extra care scheme), the thermostats in the communal areas had been disconnected for similar reasons. Similarly, while the sash windows in case study B are likely to prove difficult for persons with physical frailties to open, it was observed this was considered acceptable, as staff did not want residents to be able to open and close windows; even if they were able to, they were encouraged to ask staff members to do it for them. This suggests that further thought relating to specific care sector requirements (care and extra care) needs to be put into the design of the heating systems themselves, in terms of zoning, and the type and accessibility of controls.

Table 6: Assessment of the local design and building features within the case study buildings and their potential impact on contributing to the overheating risk

Features and hazard relevance	Case study A	Case study B	Case study C	Case study D	Examples of positive/negative aspects
Landscaping Can play a significant role in reducing overheating risk as green space and trees can create cooler microclimates (Gill *et al.*, 2007).	+	+	+	+	+ All of the case study buildings appear to have maximised areas of secure green space with limited hard surfaces onsite (only where paths and terraces are required for access). + The design of the balconies in case study D integrates planters to provide additional vegetation.
Building orientation Can have a significant effect on heat gains in summer, as the direction faced by a window, relative to south, affects how much direct sunlight it receives (Gething and Puckett, 2013).	+/–	+/–	+/–	+/–	+ Office areas (which often have most internal heat gains due to ICT equipment) were generally designed to face in a northerly direction. - In case study A, the corridor spine switches access to residents' bedrooms from left to right, ensuring the majority of bedrooms have either a southerly orientation or are inwardly facing onto the enclosed courtyard. While this enhances the visual aspects of the spaces, it could also increase the risk of overheating.
Internal layout Single-aspect apertures can reduce natural ventilation capability, while cross-ventilation increases air flow velocity, improving effect of ventilation (Santamouris and Allard, 1998).	–	–	–	–	+ All case studies had either opening external doors or windows in corridors to enable cross-ventilation. - All case studies have single-aspect residential areas with no designed provision for passive stack or cross-ventilation measures.
Construction type and materials Heavyweight construction and light (high albedo) surface materials can reduce the effect of incident solar gain (Gupta and Gregg, 2012).	+/–	+/–	+/–	+	+ All new build case studies (A, C and D) involve heavyweight wall and floor construction types (brick/block/concrete). + Case study D has a light coloured roof finish that can help reduce solar gain further. - Case studies A, B and C had low or non-reflective roof materials (low albedo).
Passive shading measures Help reduce incident solar gain (Gupta and Gregg, 2012; 2013).	+	+	+	+	+ All case studies have either internal blinds or curtains in the residential, communal and office areas. + Brise-soleil (fixed louvres) and overhanging eaves to the main south-facing communal area (case study C) and wide balconies above flats/bedrooms in case studies A and D.

Features and hazard relevance	Case study A	Case study B	Case study C	Case study D	Examples of positive/negative aspects
Lighting, appliances and electrical items Can add to internal heat gains within the building.	+/–	+/–	+/–	+/–	+ Generally all fixed lighting in the 'new' case studies designed for and installed with low wattage bulbs, with lighting being replaced in all areas of case study D with LEDs as and when the bulbs go. - Large numbers of office equipment in relatively small spaces.
Building services e.g. mechanical ventilation, communal heating and hot water systems can contribute significantly to internal heating gains.	–	–	–	–	- Communal heating systems installed in all case studies, creating significant pipework throughout communal areas. Note: appropriate design of pipework can mitigate this issue.
Control design characteristics					
Heating controls Affect ability of users to manage their thermal environment.	+	+/–	+/–	–	+ Thermostatic radiator valves (TRVs) provide localised control in all case studies. - TRVs located near floor level in all case studies except case study A, which makes it difficult to access if physically impaired. - Overly complex controls in case study D residential areas.
Ventilation controls Affect ability of users to manage their thermal environment.	+	+	+	+/–	+ Simple controls, e.g. lever handles and trickle vents. - Lever handles had to be adapted for a resident with physical frailties in case study D.
Cooling controls Affect ability of users to manage their thermal environment.	o	o	+	+	o Case studies A and B did not have specific cooling equipment. + Case study D had fixed electric ceiling fans in the communal lounge area with a simple, numbered control panel. + Both case studies C and D had air conditioning installed in some rooms (lounge/office, respectively) that appeared easy to control, although the remote control in case study C was often lost by staff and/or taken by residents.

Notes: **+** symbolises a positive feature that is likely to contribute to reducing the overheating risk; **–** symbolises a negative aspect that is likely to exacerbate the overheating risk; **o** symbolises an aspect that has a relatively neutral/negligible impact on the overheating risk.

Figure 10: Radiators covered to prevent residents' access in case study B

Reports from case study D indicated that even the standard specification and design of controls, such as lever handles, may not be wholly appropriate in the care setting, due to the physical frailties of some residents. The staff had adapted the lever handles in one flat using bike handlebars, to make them longer so that a resident with severe arthritis was still able to open and close the windows. Furthermore, the discovery that the vents in case study A had been painted over (most likely by separate maintenance staff) highlights the need for appropriate knowledge, use and management of the controls in order for them to be effective (Figure 11).

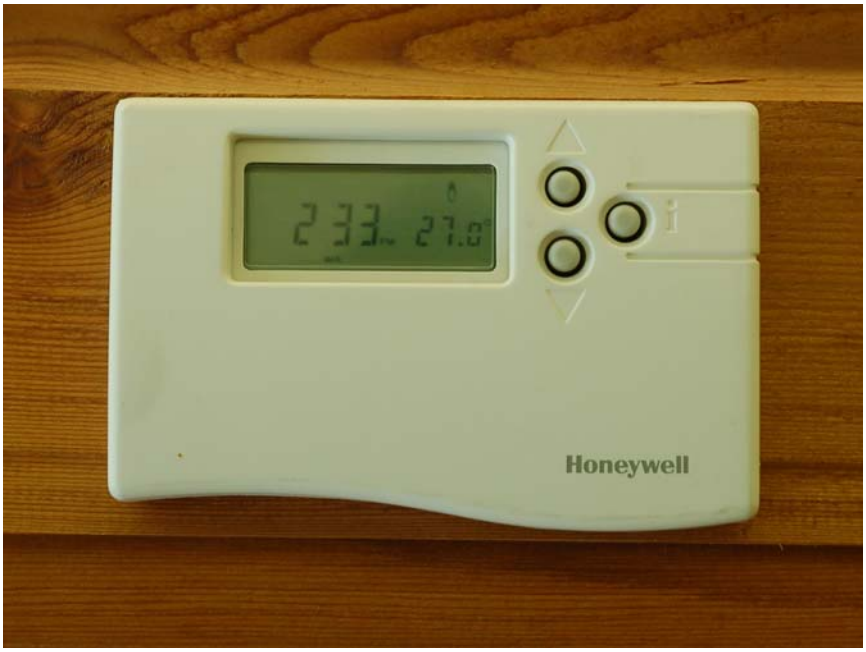
Figure 11: Trickle vent above window in bedroom cannot be opened due to being painted over and sealed closed

Despite these design and maintenance issues reducing the potential for effective use of the heating and ventilation systems, the occupants (both residents and staff) displayed signs of adapting the building to suit their thermal comfort needs, whether through residents and staff propping doors open (Figure 12) or staff creating their own window 'controls' (Figures 13). While the majority of the controls for heating, ventilation and cooling were relatively simple to operate, this did not necessarily mean they were being used in an efficient manner; an example of this was that the heating settings in the corridor areas were very high, even in summer (Figure 14).

Figure 12: Flat front door propped open to provide through-ventilation (action undertaken by both residents and staff) in case study C

Figure 13: Window propped open by staff in case study B using block of wood to provide fixed air flow

Figure 14: Thermostat in corridor set to 27°C in summer in case study C



Note: qualitative feedback suggested that thermostats had been disconnected in this case study building.

Summary

The local environmental characteristics of the case studies varied, but the main aspects that are likely to exacerbate the overheating risk are the regional location (three out of the four case studies are in the south of England), and the physical cover in the local area. None are in dense urban areas, however two (case studies A and D) are in suburban areas that have significant amounts of hard ground cover, on all sides of the sites. In contrast, case study B is in a rural location, with much less surrounding hard cover.

All case studies demonstrate a number of design features that could impact upon the risk of overheating within them (both positively and negatively). In terms of positive features, all case studies demonstrated that they have maximised landscaping (within the local environmental constraints), which can provide cooler microclimates around the building. While all the case studies have some passive shading devices, they are mainly only internal blinds or curtains, and the designs do not appear to have incorporated more innovative passive shading devices, unless necessary (such as the brise-soleil and large overhanging eaves in case study C). The exception to this is case study D, with its large balconies and vertical panels.

The majority of negative features related to the communal heating and hot water systems in place, internal layout features such as single-aspect rooms, and control-related issues such as the presence of window restrictors. It is significant that the main issues relate to the heating system and controls, as these are critical areas in which design and management can both have a significant impact in terms of contributing to, or negating, the overheating risk. A key example of this is in case study A, where the trickle vents (positive design feature) had been painted over by maintenance staff (negative management impact).

In terms of management and control, both staff and residents showed signs of adapting their physical environment to suit their thermal comfort requirements. It was also observed that in care homes, there was more staff-led control and management of heating, ventilation and cooling, while in the extra care homes, there was staff control over communal areas but residents were responsible for the control and management of their own thermal environment in residential areas (and for any reporting of issues related to this). This has consequences in terms of the types of control to be specified, and in case study D may lead to an exacerbation of the overheating risk; relatively complex heating controls were installed in the private flats, but it appeared that not only did the residents not use the main control, but due to installation issues, the thermostats had to be left on 'max'.

4 Climate modelling of current and future overheating risk

This chapter focuses on the modelling of current and future overheating risk in the four case study buildings. It first outlines the approach taken, then assesses the risks and the sensitive characteristics within each of the case studies.

Approach

Current climate conditions and future climate change projections were simulated to assess the magnitude of the risk of overheating in the care/extra care homes, using Integrated Environmental Solutions' Virtual Environment thermal calculation and dynamic simulation software. Current conditions (baseline) and future climate weather year files were used to simulate climate impact. These weather files represent average weather rather than heatwaves (or cold snaps) and have been obtained from a catalogue of weather files developed by the PROMETHEUS project (Eames *et al.*, 2011).[2] The approach taken resulted in four simulations for each site's climate risk assessment. In summary, these are:

- current conditions – baseline weather years;
- 2030s climate period, high emissions (H), 50% probability – future weather years;[3]
- 2050s climate period, high emissions (H), 50% probability (future weather years); and
- 2080s climate period, high emissions (H), 50% probability (future weather years).

Climate projections for the case study locations

A brief comparison of all weather data was made to show the expected change in external temperatures and predicted frequency of heatwaves in the case study locations. The assessments clearly showed the progression of warming throughout this century, and in terms of heatwave frequency analysis, case study A (Yorkshire and the Humber) has heatwaves predicted before others (2030s and 2050s) – partially attributed to the lower regional temperature threshold for heatwaves (PHE, 2015). However the other locations have more heatwaves, with much higher peak temperatures, in the 2080s (see Table 7). Therefore, the case studies in the south of England locations are at greater risk of overheating and heat-related health risks.

Table 7: Regional threshold temperatures (Met Office HHWS in PHE, 2015) and heatwave projections for the case study locations (May–September)

Location	Heatwave day maximum temperature threshold (°C)	Heatwave night minimum temperature threshold (°C)	Number of heatwaves	Number of heatwave periods lasting longer than 2 day minimum	Number of days with temperatures ≥ heatwave day maximum
Case study A location (Yorkshire and the Humber)					
Current climate	29	15	–	–	–
2030 H 50%			1	–	4
2050 H 50%			4	2	8
2080 H 50%			1	1	7
Case study B location (South East England)					
Current climate	31	16	–	–	1
2030 H 50%			–	–	1
2050 H 50%			–	–	1
2080 H 50%			2	1	10
Case study C location (South West England)					
Current climate	30	15	–	–	2
2030 H 50%			–	–	1
2050 H 50%			2	–	6
2080 H 50%			6	3	26
Case study D location (South East England)					
Current climate	31	16	–	–	1
2030 H 50%			–	–	–
2050 H 50%			–	–	2
2080 H 50%			4	4	21

Note: H = high emissions scenario.

Overheating risk, now and in the future

Tables 8–11 outline the modelled overheating results for the four case studies across different spaces, including residents' bedrooms, communal spaces and staff offices, using both the static and adaptive methods for defining overheating (for criteria explanations, refer to Box 2 in Chapter 2). Figure 15 summarises the results using the static method for the 2050s and 2080s. Overall the results show that:

- in case study A, both methods indicate a risk of overheating in the lounge in the 2080s (but not before), while the static method also indicates a risk in the bedrooms (from the 2050s in bedroom 3 and only from the 2080s in bedroom 1);
- in case study B, the adaptive method indicates that overheating is a risk in the lounge and one (south-east facing) bedroom from the 2030s, while the static method indicates the overheating risk is not apparent until the 2050s (although the risk is in the lounge and both bedrooms);
- in case study C, the adaptive method indicates that overheating is a risk in the lounge from the current climate onwards, and in flat 2's living room from the 2080s onwards. The static method indicates a wider risk in the building, with the lounge, manager's office and all residential areas

(bedrooms and living rooms) overheating in the 2080s, with overheating in some rooms from the 2050s; and

- in case study D, both methods only indicate overheating in the 2080s, although the static method indicates that most rooms will overheat, whereas the adaptive method indicates only the lounge will overheat in this period. It must be noted that the building survey indicated faults with the heating system that are likely to contribute to the overheating risk in reality, but the modelling assumes that these issues have been resolved.

Table 8: Case study A

	Adaptive method (TM52 criteria failed)				Static method (% of occupied hours over temperature threshold)			
	Current climate	2030	2050	2080	Current climate	2030	2050	2080
Lounge/dining room (FF, north)	–	–	2	1 & 2	–	0.2	0.9	1.0
Manager's office (GF, north)	–	–	–	–	–	–	–	–
Bedroom 1 (GF, south)	–	–	–	–	–	–	0.2	0.4
Bedroom 3 (FF, south-east)	–	–	2	2	–	0.4	1.0	1.7

Notes:
Boxes shaded dark purple did not show signs of overheating; boxes shaded light purple showed signs of overheating.

GF = ground floor
FF = first floor

Table 9: Case study B

	Adaptive method (TM52 criteria failed)				Static method (% of occupied hours over temperature threshold)			
	Current climate	2030	2050	2080	Current climate	2030	2050	2080
Lounge 2 (GF, north-east)	2	2 & 3	1 & 2	1, 2 & 3	0.1	0.2	1.4	3.6
Staff office (basement, north-west)	–	–	–	–	–	0.1	0.1	0.7
Bedroom 1 (GF, north-west)	–	2	–	2	0.2	0.2	1.2	3.2
Bedroom 3 (FF, south-west)	2	2 & 3	2	1, 2 & 3	0.3	0.7	2.2	4.6

Notes:
Boxes shaded dark purple did not show signs of overheating; boxes shaded light purple showed signs of overheating.

GF = ground floor
FF = first floor.

Table 10: Case study C

	Adaptive method (TM52 criteria failed)				Static method (% of occupied hours over temperature threshold)			
	Current climate	2030	2050	2080	Current climate	2030	2050	2080
Lounge 1 (GF, south)	2 & 3	1 & 2	1, 2 & 3	1, 2 & 3	0.5	0.9	1.8	6.6
Manager's office (GF, south-east)	–	–	–	2	–	–	0.8	4.7
Flat 1 bedroom (GF, south-west)	–	–	2	2	0.1	0.2	1.0	4.5
Flat 1 living room (GF, south-west)	not occupied				not occupied			
Flat 2 bedroom (FF, north-east)	–	–	–	–	–	–	0.4	2.0
Flat 2 living room (FF, north-east)	–	–	2	1, 2 & 3	–	0.2	1.0	3.8

Notes:
Boxes shaded dark purple did not show signs of overheating; boxes shaded light purple showed signs of overheating.

GF = ground floor
FF = first floor

Table 11: Case study D

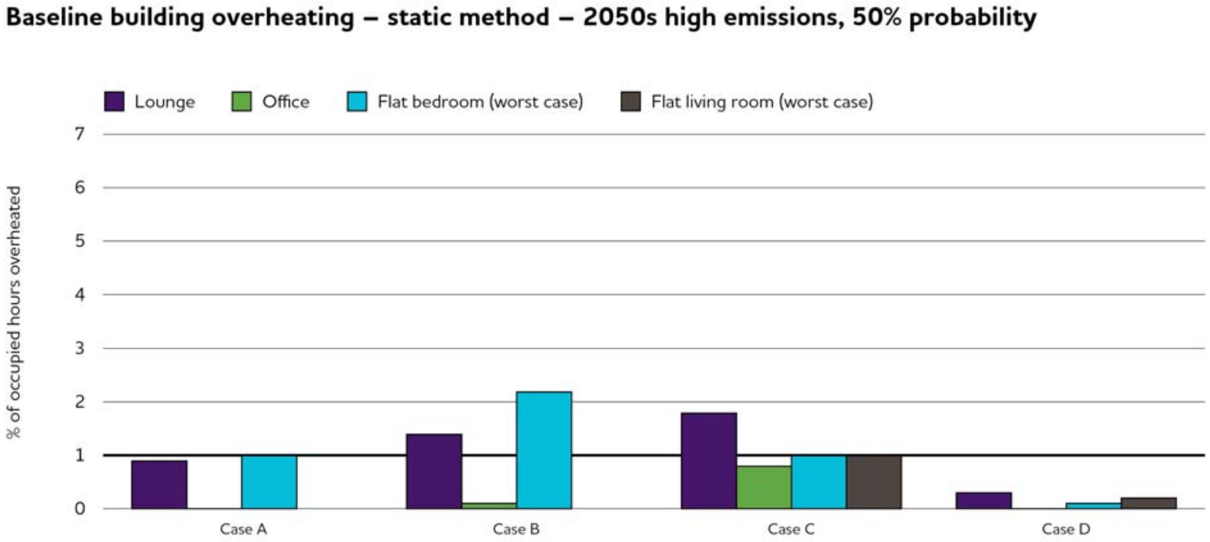
	Adaptive method (TM52 criteria failed)				Static method (% of occupied hours over temperature threshold)			
	Current climate	2030	2050	2080	Current climate	2030	2050	2080
Lounge 1 (uGF, south-east/ south-west	–	–	–	1 & 2	–	–	0.3	5.6
Staff office (SF, south-west)	–	–	–	–	–	–	–	–
Flat 1 bedroom (FF, south-east)	–	–	–	–	–	–	0.1	1.2
Flat 1 living room (FF, south-east)	–	–	–	2	–	–	0.2	2.0
Flat 3 bedroom (TF, south-east)	–	–	–	–	–	–	–	3.3
Flat 3 living room (TF, south-east)	–	–	–	–	–	–	–	2.7

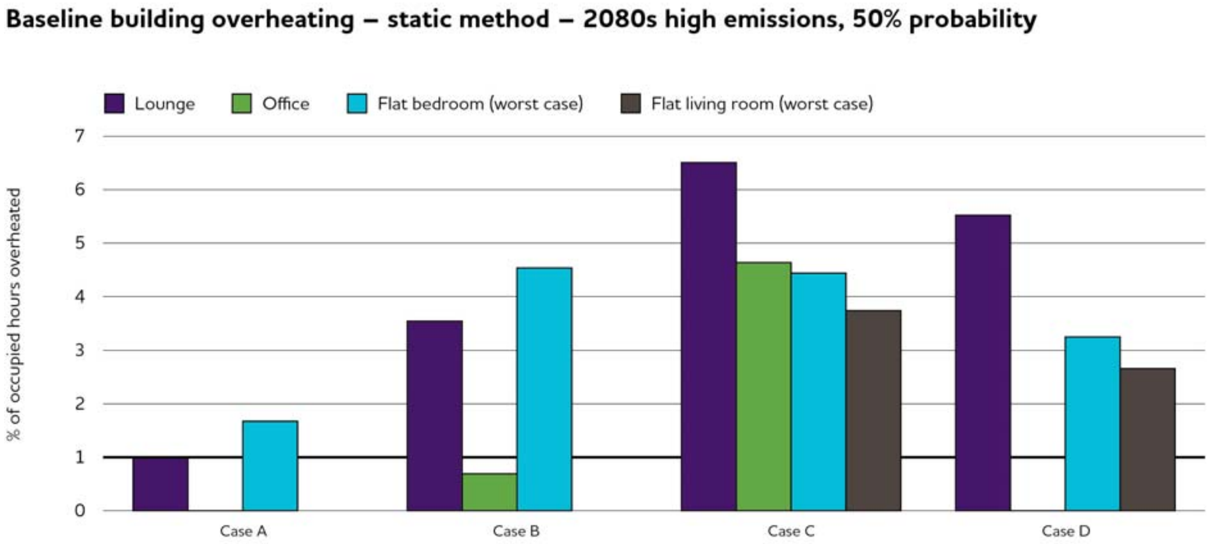
Notes:
Boxes shaded dark purple did not show signs of overheating; boxes shaded light purple showed signs of overheating.

During building surveys some bathrooms in case study D were found to be heated during the summer months, due to issues with the heating system. The modelling and simulation, however, assumes that this practice has been fixed.

uGF = upper ground floor
FF = first floor
SF = second floor
TF = third floor

Figure 15: Static overheating summary results





Identifying sensitive characteristics

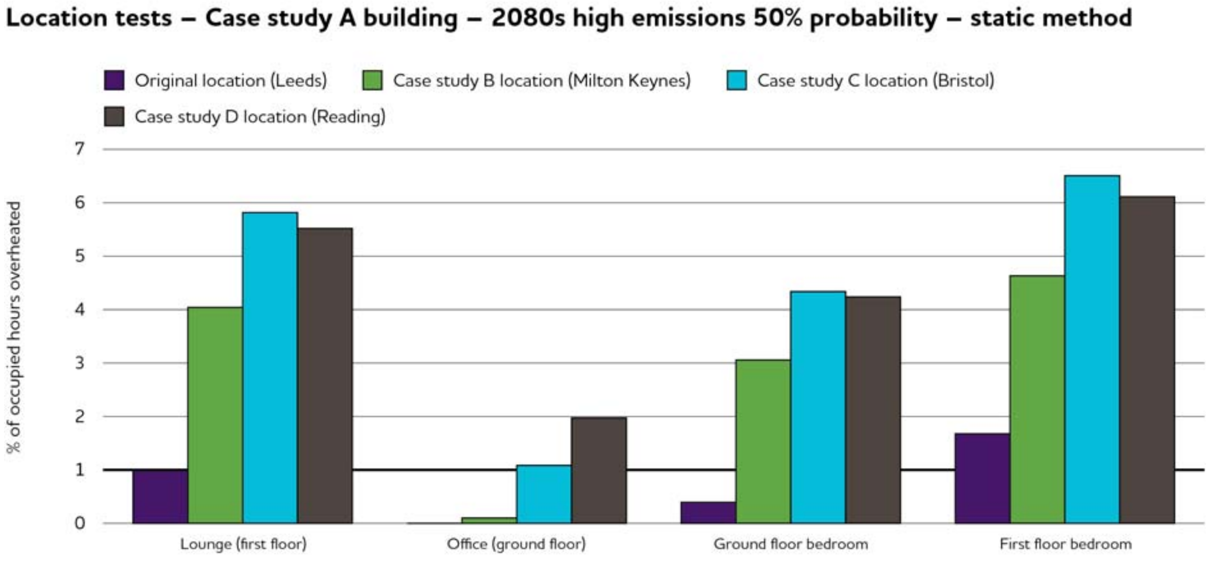
The following characteristics were tested to identify which variations may lead to a higher risk of overheating in care/extra care homes:

- location; and
- orientation.

Location

The impact of location on overheating risk can vary greatly. To demonstrate this, case study A was simulated in all four locations. Figure 16 shows the difference location plays in overheating potential for the 2080s climate period. Case study C's location (South West England) appears to present the highest overheating risk, followed closely by case study D's location (South East England). Interestingly, the slight difference between these two locations is reversed when assessing the results using the adaptive method. Also note that overheating in the office is higher in the case study D location than in the case study C location.

Figure 16: Location change for case study A



Orientation

The orientation of certain spaces can also have an impact on overheating results with regard to whether solar angles and wind direction can be absorbed or deflected, depending on need. Obviously in existing buildings orientation can be difficult to change; however, if there is flexibility, understanding orientation can guide where to place certain individuals based on vulnerability. For new constructions, consideration of orientation is very important in designing a building where sustainability is seriously considered. To demonstrate an example of this impact on overheating results, case study C was simulated in four additional orientations (Figure 17). Table 12 shows the difference changing orientation alone has on overheating potential for the 2080s climate period. This test demonstrates (as far as overheating risk is concerned) that:

- the lounge was correctly orientated originally, although it overheats significantly;
- all other spaces would have benefited from north-east or north orientation; and
- bedrooms (spaces occupied in the evening and at night) would benefit from avoiding west (including south-west and north-west) orientations due to the late solar gain; spaces occupied during the daytime, e.g. offices and living rooms, are more susceptible to overheating when facing south-east and east.

Figure 17: Orientation change for the case study C model

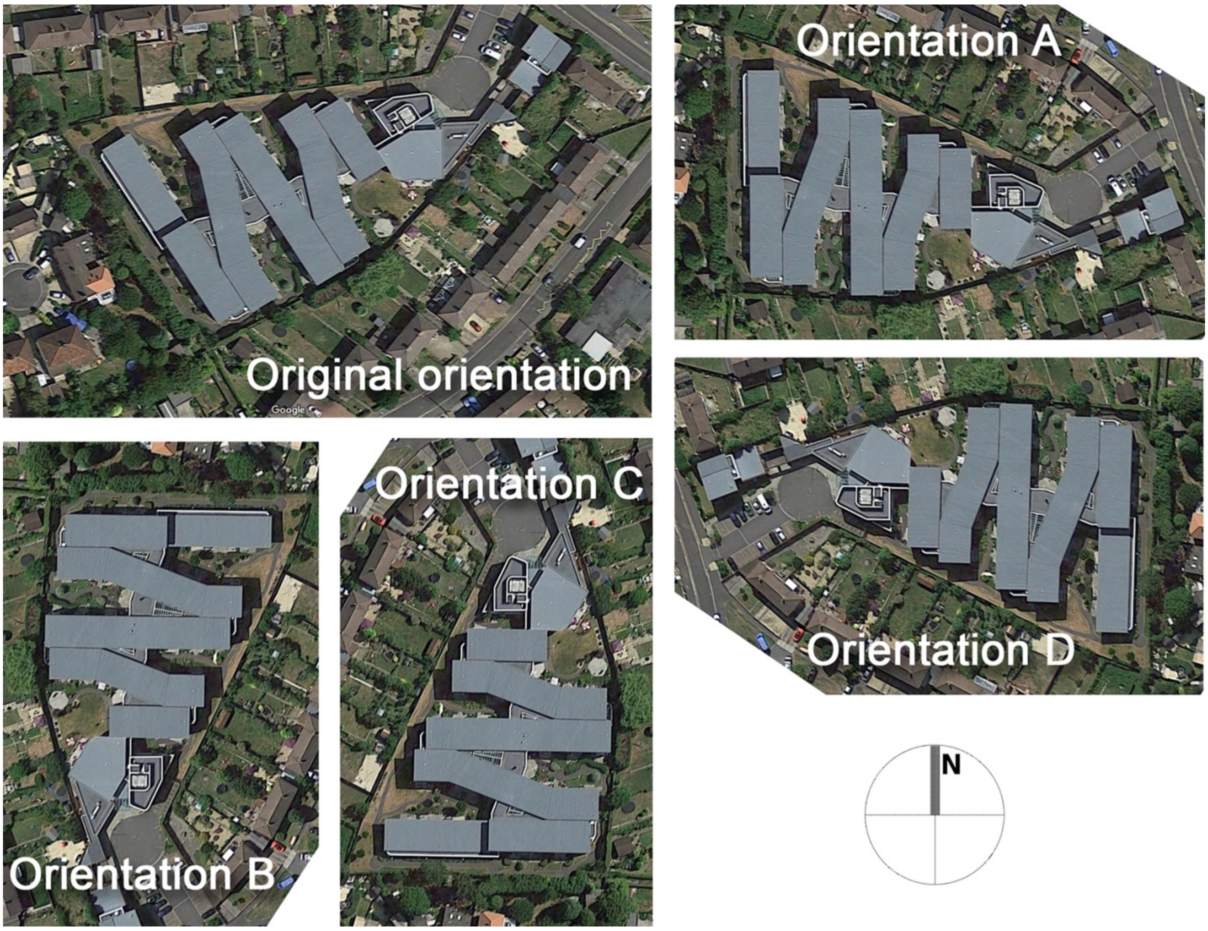


Table 12: Orientation change for case study C results

CIBSE, 2006 (static method)	Original		Orientation A		Orientation B		Orientation C		Orientation D	
	Face	2080	Face	2080	Face	2080	Face	2080	Face	2080
Lounge 1 (GF)	S	6.6	SW	+0.5	NW	+0.5	SE	+0.3	NE	+0.1
Manager's office (GF)	SE	4.7	S	-0.4	W	-0.2	E	-0.6	N	-0.8
Flat 1 bedroom (GF)	SW	4.5	W	-0.2	N	-0.9	S	-0.5	E	-0.7
Flat 2 bedroom (FF)	E	2.0	SE	+0.1	SW	+0.3	NE	–	NW	+0.3
Flat 2 living room (FF)	E	3.8	SE	-0.3	SW	-0.3	NE	-0.7	NW	-0.3

Notes:
Boxes shaded light purple show 'worst' orientation; dark purple indicates 'best' orientation.

GF = ground floor
FF = first floor.

Summary

Heatwaves (as defined in the Heatwave Plan for England (PHE, 2015) and based on the Met Office's HHWS) and longer periods of external temperatures above 25°C are projected to be common occurrences by the 2050s climate period, particularly in the south of England locations.

Modelling indicates that overheating is largely an issue for the future, rather than the current climate (the only exception being the case study C lounge). Case studies B (South East England) and C (South West England) appear to be at most risk (overheating in some areas from the 2030s), while case studies A and D (Yorkshire and the Humber, and South East England, respectively) are not predicted to overheat in any area until the 2080s. However, the model excluded the issue with the heating system that was identified through the building survey in case study D, which would otherwise amplify the risks. In addition, there were differences between the predictions using the adaptive and static methods, with the static method (as expected) predicting a wider spread of rooms at risk of overheating across the case studies.

Location will impact significantly on overheating resilience, as homes in the south of England will become more susceptible to overheating with climate change. For this reason it may be necessary to focus more immediate effort in the south of England.

Evaluation of the impact of orientation indicates that both south-east and south-west facing spaces are more susceptible to overheating in the future. The study also indicates that the risk could be reduced by rooms with particular functions being orientated appropriately; for example, bedrooms would benefit from avoiding west orientations due to the late solar gain, while spaces occupied during the daytime are more susceptible to overheating when orientated south-east or east.

5 Measuring overheating risk

This chapter outlines the findings from the monitoring of internal and external environmental conditions of the four case study buildings in the summer of 2015. The monitoring was undertaken for a period of approximately three months, and focused on temperature as well as indoor air quality. The chapter first summarises the findings from the monitoring of environmental conditions (temperature, relative humidity and CO_2 levels), and then provides an analysis of the current measured overheating risk in the buildings.

Indoor environmental conditions

Thermal environmental conditions: comfort and health

Overall, across the four case studies, the temperatures in 17 residential rooms (six living rooms in extra care units, and 11 bedrooms) were monitored, along with eight communal areas and eight office areas. Tables 13–16 show the mean and maximum temperatures across the areas within each case study.

Table 13: Mean and maximum indoor temperatures in case study A across the monitoring period

Case study A		Temperature (°C)	
		Mean	Maximum
Residential areas	Bedroom 1 (GF, south facing)	24.7	27.2
	Bedroom 2 (GF, west facing)	24.0	28.0
	Bedroom 3 (FF, south-east facing)	23.8	28.8
Communal areas	Lounge/dining room (FF, north/north-west facing)	23.5	31.2
Office areas	Staff office (GF, north-west/north facing)	26.4	30.1
	Manager's office (GF, north facing)	24.9	28.1

Notes:
Boxes shaded purple are above the recommended comfort and overheating threshold temperatures (bedrooms = 23°C/26°C; living and office areas = 25°C/28°C).

GF = ground floor
FF = first floor

Table 14: Mean and maximum indoor temperatures in case study B across the monitoring period

Case study B		Temperature (°C)	
		Mean	Maximum
Residential areas	Bedroom 1 (GF, north-west facing)	23.1	28.1
	Bedroom 2 (FF, north-east facing)	23.0	26.6
	Bedroom 3 (FF, south-west facing)	24.3	29.8
Communal areas	Lounge 1 (GF, south-west facing)	23.5	30.3
	Lounge 2 (GF, north-east facing)	23.7	26.7
Office areas	Staff office (basement, north-west facing)	24.8	26.9
	Manager's office (basement, south-west facing)	24.9	31.3

Notes:
Boxes shaded purple are above the recommended comfort and overheating threshold temperatures (bedrooms = 23°C/26°C; living and office areas = 25°C/28°C).

GF = ground floor
FF = first floor

Table 15: Mean and maximum indoor temperatures in case study C across the monitoring period

Case study C		Temperature (°C)	
		Mean	Maximum
Residential areas	Flat 1 (bedroom, GF, south-west facing)	24.7	28.3
	Flat 1 (living room, GF, south-west facing)	25.0	29.1
	Flat 2 (bedroom, FF, east facing)	24.9	29.6
	Flat 2 (living room, FF, east facing)	24.4	30.0
	Flat 3 (bedroom, FF, west facing)	24.0	30.1
	Flat 3 (living room, FF, west facing)	24.4	29.4
Communal areas	Lounge 1 (GF, south-facing)*	25.2	28.4
	Lounge 2 (GF, south-east facing)	25.8	30.2
Office areas	Staff office (GF, north-east facing)	24.4	28.7
	Manager's office (GF, south-east facing)	26.6	30.3

Notes:
Boxes shaded purple are above the recommended comfort and overheating threshold temperatures (bedrooms = 23°C/26°C; living and office areas = 25°C/28°C).

* This lounge has air conditioning and electric fans.

GF = ground floor
FF = first floor

Table 16: Mean and maximum indoor temperatures in case study D across the monitoring period

Case study D		Temperature (°C)	
		Mean	Maximum
Residential areas	Flat 1 (bedroom, FF, south-east facing)	25.9	30.2
	Flat 1 (living room, FF, south-east facing)	26.7	30.9
	Flat 2 (living room, SF, south-east facing)	25.4	30.6
	Flat 3 (bedroom, TF, south-east facing)	26.9	30.6
	Flat 3 (living room, TF, south-east facing)	27.1	30.7
Communal areas	Lounge 1 (uGF, south-east/south-west facing)	26.1	31.3
	Lounge 2 (SF, north-east facing)	24.4	29.6
	Dining room (lGF, north-east facing)	25.6	30.2
Office areas	Staff office (SF, south-west facing)	27.1	29.8
	Manager's office (lGF, no external windows)*	25.9	27.8

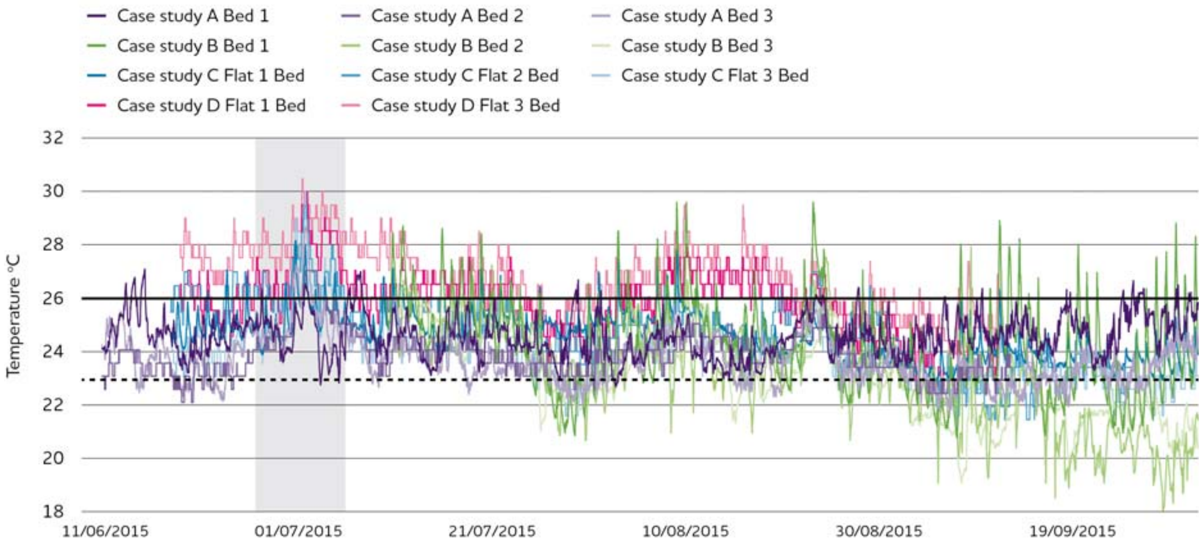
Notes:
Boxes shaded purple are above the recommended comfort and overheating threshold temperatures (bedrooms = 23°C/26°C; living and office areas = 25°C/28°C).

* This office has air conditioning and electric fans.

lGF = lower ground floor
uGF = upper ground floor
FF = first floor
SF = second floor
TF = third floor

There were significant periods in most bedrooms, particularly in the extra care units (case studies C and D), where temperatures were above 26°C (the maximum threshold temperature for both PHE 'cool room' guidance and CIBSE Guide A; see Figure 18). The average mean temperature across all bedrooms monitored was 24.5°C; this is higher than the CIBSE (2015) guidance temperature of 24°C, above which thermal comfort and quality of sleep decreases.

Figure 18: Indoor temperatures in monitored bedrooms in all case study buildings across the monitoring period (June–September 2015)

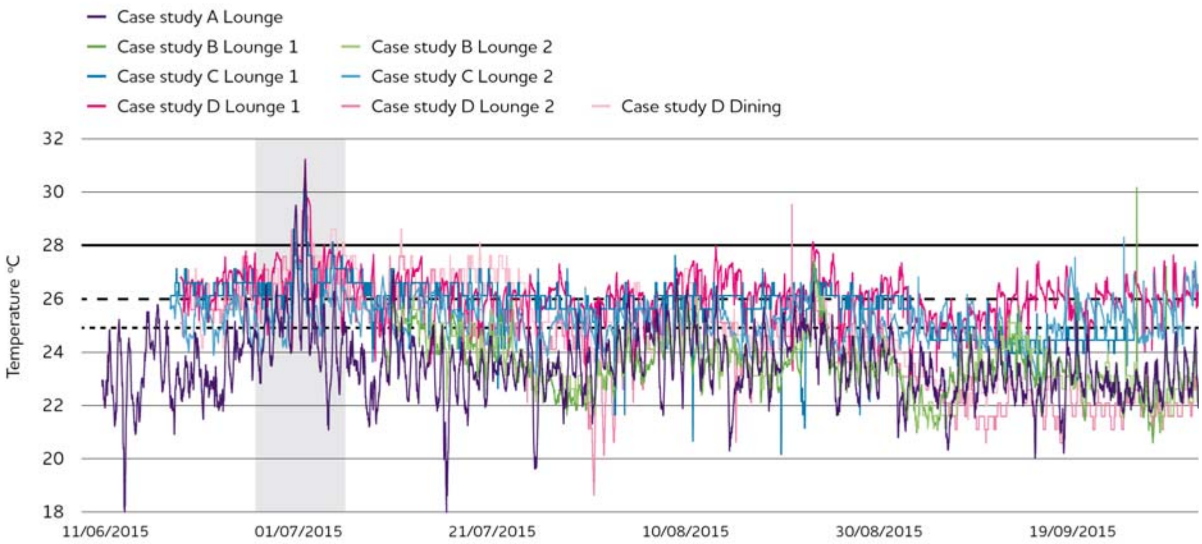


Note: The vertical red band indicates a period of high external temperatures across case studies; the red horizontal solid line indicates the maximum comfort threshold temperature; the horizontal blue line indicates the summer comfort indoor temperature (CIBSE, 2006); the dashed horizontal red line indicates the PHE Heatwave Plan recommended threshold temperature for 'cool areas'.

In the residential living rooms (only in case studies C and D), the temperatures in case study C were generally higher than the operative temperature for indoor comfort in summer (25°C; CIBSE, 2006), and there were some instances of temperatures above 28°C (maximum threshold temperature; CIBSE, 2006). In case study D, temperatures were significantly higher throughout the summer, with several periods in which the temperature was above both the comfort and overheating threshold temperatures. The average mean temperature across the six living rooms was 25.5°C.

The communal areas (shared lounges and dining rooms) were generally below the maximum threshold temperature for such areas, with an average mean temperature of 24.7°C. However, Figure 19 also highlights that there are significant periods throughout the monitoring period where temperatures were over 26°C (the Heatwave Plan recommended 'cool room' maximum threshold temperature). The office areas were generally higher than the indoor summer comfort temperature and had an average mean temperature of 25.7°C.

Figure 19: Indoor temperatures in monitored communal areas in all case study buildings across the monitoring period (June-September 2015)



Note: The vertical red band indicates a period of high external temperatures across case studies; the red horizontal solid line indicates the maximum comfort threshold temperature; the horizontal blue line indicates the summer comfort indoor temperature (CIBSE, 2006); the dashed horizontal red line indicates the PHE Heatwave Plan recommended threshold temperature for 'cool areas'.

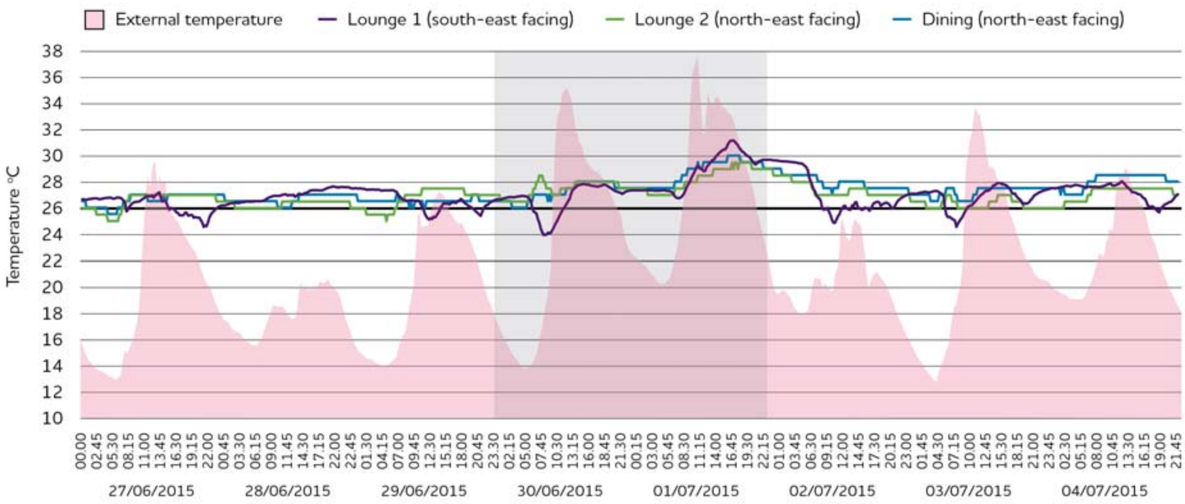
Across the monitoring period (highlighted in Figures 17 and 18 by a red vertical band), there were significant 'spikes' in indoor temperatures within the residential and communal areas, across the case study buildings.

These spikes correlated with higher outdoor temperatures. In two case study areas (A and D), the 'spikes' correlated with recorded outdoor temperatures above PHE's HHWS threshold temperatures (day and night), indicating a heatwave period.

Looking in detail at the indoor temperatures during the heatwave period can give insight on the preparedness and resilience of the building in terms of preventing thermal discomfort, and reducing heat-related health risks. Using case study D as an example (Figure 20), indoor temperatures were already above the Heatwave Plan recommended threshold temperature of 26°C prior to the heatwave. Within the first day of the heatwave period, indoor temperatures in the residential and communal areas rose by a further 2°C. On the second day the temperatures rose again, and even after the heatwave had passed, indoor temperatures remained high. This indicates that existing ventilation and cooling strategies and management within these areas do not provide adequate overnight cooling. None of the monitored rooms in the two case studies could be used as 'cool areas', as recommended by the Heatwave Plan for England, without additional heating management as well as further ventilation and cooling methods.

The 'spikes' were not as evident within the office areas, and the data indicates that internal heat gains (from occupants and ICT equipment) have a greater effect on temperatures in these rooms than outdoor temperatures.

Figure 20: Outdoor and indoor communal area temperatures in case study D over short-term heatwave period



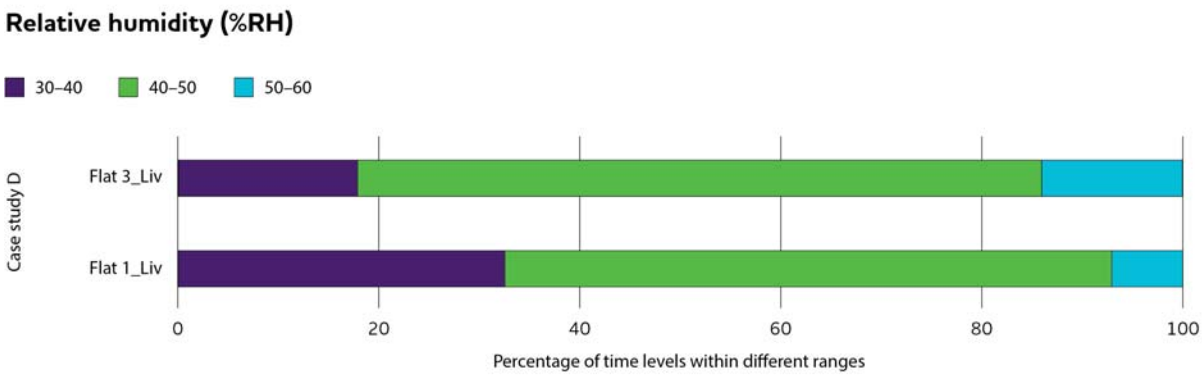
Note: The red dotted horizontal line outlines the threshold temperature for PHE recommended 'cool areas' during a heatwave period.

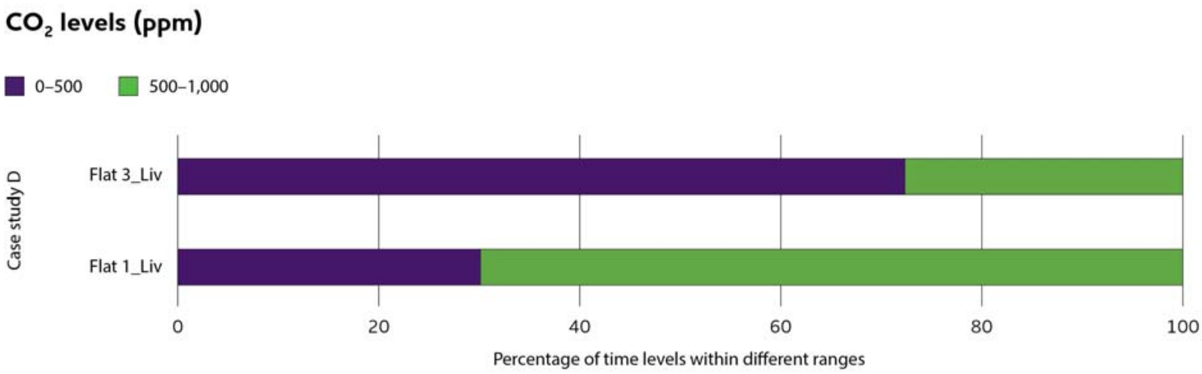
CO_2 and relative humidity levels

CO_2 and relative humidity (RH) levels were monitored in ten of the residential areas (six bedrooms and four living rooms), four communal areas and seven office areas, to provide an overview of the indoor environmental conditions. These variables allow for assessment of indoor air quality and assist in the understanding of ventilation capacity.

There were few instances of CO_2 and RH levels outside the acceptable range; as Figure 21 shows, even in case study D, where temperatures within the bedrooms were generally high, both CO_2 and RH levels are comfortably within acceptable limits (40–70% RH and below 1,000ppm for CO_2) for the majority of the time monitored.

Figure 21: RH and CO_2 level ranges in monitored residential areas in case study D across the monitoring period (June–September 2015)





Current overheating risk

Table 17 outlines the results from the overheating analysis of the monitoring data. Although the majority (16 out of 17) of the residential rooms overheated according to the static method, only three rooms (in case study C) showed overheating according to the adaptive method. All of the communal rooms overheated according to the static method, although only three rooms (in case study D) showed overheating according to the adaptive method. Four of the eight office rooms overheated according to the static method, but only one (case study B manager's office) showed overheating according to the adaptive method.

Case studies A and D have the most rooms overheating, according to the static method. However, case studies C and D indicate the most rooms overheating according to the adaptive method. It is likely that issues with the heating system in case study D, and a subsequent lack of control, added significantly to the overheating of the monitored rooms. Interestingly, external temperatures used in the analysis of case study C did not indicate any heatwave period, yet three of the six residential areas monitored were found to be overheating, according to the adaptive method (which uses external temperature data).

Table 17: Results from the adaptive (CIBSE, 2013) and static (CIBSE, 2006) overheating methods analysis of monitored areas in all case study buildings

		Adaptive method (TM52 criteria failed)	Static method (% of occupied hours over temperature threshold)		Adaptive method (TM52 criteria failed)	Static method (% of occupied hours over temperature threshold)
Case study A				**Case study B**		
Residential areas	Bedroom 1 (GF, south facing)	–	6.3	Bedroom 1 (GF, north-west facing)	–	7.9
Residential areas	Bedroom 2 (GF, west facing)	–	2.7	Bedroom 2 (FF, north-east facing)	–	1.4
Residential areas	Bedroom 3 FF, south-east facing)	–	2.2	Bedroom 3 (FF, south-west facing)	1	16.7
Communal areas	Lounge/dining room (FF, north/ north-west facing)	–	1.0	Lounge 1 (GF, south-west facing)	–	0.0
Communal areas				Lounge 2 (GF, north-east facing)	–	0.0
Office areas	Staff office (GF, north-west/ north facing)	1	1.6	Staff office (basement, north-west facing)	–	0.0
Office areas	Manager's office (GF, north-facing)	–	0.0	Manager's office (basement, south-west facing)	1 & 2	14.6
Case study C				**Case study D**		
Residential areas	Flat 1 (bedroom) (GF, south-west facing)	–	6.0	Flat 1 (bedroom) (FF, south-east facing)	1	49.9
Residential areas	Flat 1 (living room) (GF, south-west facing)	1, 2 & 3	1.4	Flat 1 (living room) (FF, south-east facing)	1	9.3
Residential areas	Flat 2 (bedroom) (FF, east facing)	1, 2 & 3	24.1	Flat 2 (living room) (SF, south-east facing)	1	3.2
Residential areas	Flat 2 (living room) (FF, east facing)	1 & 2	1.0	Flat 3 (bedroom) (TF, south-east facing)	1	76.0
Residential areas	Flat 3 (bedroom) (FF, west facing)	–	5.0	Flat 3 (living room) (TF, south-east facing)	1	17.6
Residential areas	Flat 3 (living room) (FF, west facing)	–	0.2			
Communal areas	Lounge 1 (GF, south facing)	–	0.0	Lounge 1 (uGF, south-east/ south-west facing)	1 & 3	1.1
Communal areas	Lounge 2 (GF, south-east facing)	1	1.1	Lounge 2 (SF, north-east facing)	1 & 3	1.4
Communal areas				Dining room (IGF, north-east facing)	1 & 3	4.4
Office areas	Staff office (GF, north-east facing)	–	0.4	Staff office (SF, south-west facing)	–	4.1
Office areas	Manager's office (GF, south-east facing)	1	10.6	Manager's office (IGF, no external windows)	–	0.0

Notes:
Boxes shaded dark purple did not show signs of overheating; boxes shaded light purple showed signs of overheating.

lGF = lower ground floor
uGF = upper ground floor
FF = first floor
SF = second floor
TF = third floor

Summary

The monitoring of indoor environmental conditions revealed that, generally (across case studies A, C and D in particular), indoor temperatures were high for prolonged periods of time, especially in bedrooms, where the average temperature was 24.5°C across the monitoring period and regularly reached higher temperatures than recommended static comfort levels (CIBSE, 2015). There were also significant periods in which the indoor temperatures in the residential (bedrooms and private living rooms) and communal areas were above the Heatwave Plan's recommended threshold temperatures for 'cool rooms'. This indicates that alongside probable thermal discomfort for the occupants, there was a significant likelihood of heat-related health risks throughout the period.

Indoor temperatures significantly increased in the residential and communal areas (but not as significantly in office areas) in all case studies during periods of hot outdoor temperatures. This highlights the overheating risk during heatwaves, and the necessity for adequate preparedness and management of indoor temperatures during periods of high external temperatures.

Overheating is currently happening in all the case study buildings, particularly the three 'new' buildings (even case study A, which is located in the north of England) that have higher airtightness and insulation levels. Overall, all case studies appear to have most issues with overheating in residential areas (private bedrooms and living rooms).

Overheating appears to occur more in the extra care buildings (case studies C and D), particularly in the residential (case study C) and communal areas (case study D), which overheat according to both the static and adaptive methods. Case study D has the most overheating, which is likely to be due to issues with the installation and management of the heating system.

There is a significant difference in the numbers of rooms overheating according to the static (25 out of 33) and adaptive (7 out of 33) methods. All rooms reach above the Heatwave Plan 'cool room' threshold temperature of 26°C at least once during the monitoring period. This highlights the need for alignment between the construction and care/health sector guidance on thermal comfort and health risks, particularly in terms of the care sector's more vulnerable occupants.

6 Stakeholder perspectives: design, management and use

This chapter outlines the findings from interviews with five designers/architects, four asset managers, four care scheme managers, seven carers, two building maintenance staff and ten residents in the four case study schemes. It also looks at the re-analysis of interview data (63 interviewees) from a previous study (*Conditioning demand*) to gather insights on the design intent, management and care practices, and resident experiences in both care and extra care settings, in the context of addressing heat and thermal comfort.

Design intent and briefing

Awareness and attitudes towards future climate change and overheating

There appeared to be a general lack of awareness of the risks of climate change, particularly in relation to overheating, in the design and construction industry. As one designer stated, when designing and developing the brief for care schemes, overheating is "the poor sister… to other aspects of climate change". Designers were generally unaware of the formal PHE Heatwave Plan for England guidance. While all those interviewed considered designing for overheating to simply be 'good environmental design', one designer said:

> We need to understand it a little bit more… we're not as familiar with the solutions… it's not just us I think, that's the industry as a whole.
> Architect

Overheating and future climate change was simply not on the radar of most of the asset managers (or the organisations for which they worked). In part, this appeared to be due to attitudes towards strategic planning, and the fact that most did not consider overheating to be an issue within the time period:

> When we build today… I am thinking of 30 years. If climate change puts the average temperature up by one or two degrees in those 30 years… fine, we might do something about it, but I don't know.
> Development director

Despite this, the sustainability manager from case study A indicated that overheating was becoming more of an issue, not just for new build schemes but also for refurbishments, and that their strategic plan was over a 60-year period to accommodate this, to provide effective adaptive and resilient long-term strategies for their existing and future care/housing schemes. While overheating was not on the agenda when case study A was being designed, it is now becoming part of the organisation's strategic planning.

There was also an underlying attitude among both designers and managers that emphasised a culture of 'warmth'; cold is seen as an issue, and as such there was a focus in both the design and briefing documents for new schemes on provision of warmth, rather than provision of cooling and/or adequate ventilation strategies:

> We haven't thought about AC or the environment getting too warm… we're probably more concerned about things being cold in winter rather than warm in summer.
> Managing director

Low prioritisation of overheating and future climate change

Care, financial and spatial requirements were the main priorities for all the case study care schemes, and both briefing requirements and designs of existing and future developments reflected this. As many of the respondents commented, this could (and had) led to conflicts in terms of designing for overheating and future climate change, and perceived additional expense:

> You can build for £1,500 per square metre, why are you costing me £1,650 per square metre?
> Development director

A further conflict raised was in relation to the need to centralise services; hot water is constantly required, and as such is often circulated (adding to internal heat gains) around the building, all year round. Furthermore, practical requirements such as health, safety and security that are specific to the care sector also took priority over overheating and adaptation strategies (e.g. window restrictors on windows, see Figure 22).

Figure 22: Device to restrict window-opening

Conflicting advice, calculations and standards

Modelling and relevant overheating standards were an area of focus within the interviews, particularly with the designers. Many interviewees commented on the fact that there is no clear definition or guidance on overheating to which designers can both design and refer clients. Since all the case studies were constructed there has been an increase in standards and guidance (such as CIBSE, 2013, and Building Regulations Part L2A 2013 – non-domestic, but includes provision for domestic buildings that fall outside Part L1A, such as care homes) in terms of assessing the overheating risk in new buildings. However, there is still no definitive regulatory requirement in the building sector; even the Part L regulation is not strictly an overheating methodology, as it places a limit on solar gains and does not assess the indoor temperature. Some of the designers emphasised the fact that much of the building-related guidance refers to thermal comfort, and not overheating specifically; the implication being that overheating is much more than just thermal comfort, particularly in terms of the related health risks.

Two out of the three design practices interviewed left the design of services and modelling of thermal comfort with either environmental consultants or mechanical and electrical engineers, which appears to have led to a lack of a joined-up approach between the overall design of the buildings and the services design (heating, hot water and electrical systems).

Disconnect between design intent and actual management of systems

Procurement routes such as 'design and build' (see Glossary for further details) are often preferred by medium-to-large care housing providers (housing associations and private care home providers) as this provides a single primary contractor throughout the process of developing and delivering a new building. However, several interviewees stated that it resulted in a separation between design intent and technical specification, and, in particular, the installed services and systems. Often, specifications are unclear, and the final design and detailed specification is left with individual subcontractors, who do not necessarily communicate with the subcontractors for other elements. This can potentially lead to conflicts in pipework routes for different services, and result in a lack of efficiency. Furthermore, such a process can lead to decisions, mainly cost-driven, that conflict with the original design intent, and potentially accentuate the overheating risk. For example, in case study C the preferred design of the roof was concrete (providing thermal mass), but a timber roof (with little thermal mass and no roof void to enable the absorption of heat) was installed due to value engineering.

A lack of communication between all parties can also exacerbate issues relating to heating and ventilation systems, particularly in terms of ensuring the end users are aware of the systems installed, and how to control and use them effectively. Often the design of the heating and ventilation systems is left with separate mechanical and electrical services engineers and consultants, as in case study A where the architects were reliant on the consultants hired to undertake all the commissioning, testing and checking, but who were not responsible for the handover of the building to the end users. This can result in a lack of information provided to the end users in how to operate systems, often leading to a lack of knowledge about how the systems work. In addition, due to the often complex management structures of the care sector (in medium-to-large organisations), handover of the building and services is unlikely to be done with the onsite, day-to-day users, but rather with separate offsite management and/or maintenance teams. Such a process can further separate the day-to-day users of the building from the heating and ventilation systems within, increasing the lack of onsite knowledge of how to use the systems effectively. Interviewees indicated that this issue was further exacerbated by high staff turnover and shift work in care settings, which makes it difficult to plan and provide training to all staff.

There appeared to be a preference for remote and centralised building management systems by high level managers of medium-to-large care organisations, as it provides them with an overview of energy use and enables responsive maintenance across a number of schemes. However, it was recognised that such systems do not always work in accordance with expectations (due to poor commissioning); they are often complex to manage, and can reduce control of frontline staff.

Such issues increase the potential for lack of communication between staff, and create uncertainty over who is responsible for the systems in the building. The study revealed cases of ‘passing the buck’, where the onsite care manager indicated that the responsibility of the heating system was with the offsite management and maintenance teams, and did not see the overall control of the heating system as part of their role, while the maintenance staff did not recognise managing the system as part of their job either.

Management and care practices

Health risks and heat

Echoing the views of designers and asset managers, onsite managers and care staff expressed scepticism about the risk to occupants’ health from heatwaves, partly because these were regarded as rare in the UK, and partly because the principal health risks were believed to come from cold conditions. There is thus a strong culture in which the cold is considered dangerous, warmth is related to good care, and excessive heat is tolerated as a choice of residents. One care scheme manager, explaining why all occupants pay the same for heating regardless of how much they use, said:

> It encourages them to put the heater on if they’re cold, because that’s the biggest killer in the elderly is the cold.

There was also a perception that older people ‘feel the cold’, and that older occupants are unlikely to ever complain of being too hot. One carer suggested that older occupants, “even in summertime [wear] cardigans, jumpers, blankets over their knees” because “their skin's a lot thinner”.

Staff feeling too hot was a major issue in all care homes. The areas where residents live are very warm, and staff areas like kitchens, laundries and offices are often even hotter. Staff, including managers, considered the need to tolerate this heat to be part of their job, although it raises concerns about the health of staff. Some residents interviewed for the study reported that they did not like living in a warm building, although others appreciated the warmth.

Operation of heating systems

The study found a lot of confusion about how heating systems work, how to control them and who was responsible for adjustments, across all four case studies and from the secondary analysis of the *Conditioning demand* study. Heating systems in large buildings, particularly those with underfloor heating and/or building management systems, can be very slow to respond to adjustments or have confusing interfaces/controls. This can lead to contradictory actions (windows open with the heating on full) or inaction by staff that can contribute to overheating. Some care staff felt they were not allowed to adjust the heating system. In one care home, nobody knew who was responsible for switching the heating system on and off, and for setting the timer.

In all four of the primary case studies, buildings were heated by communal heating systems. In every case, the heating was in operation throughout the summer. Some managers and carers argued that it was better to do this, and rely on room thermostats and thermostatic valves to 'switch off' the heating in individual rooms when the temperature rose above specified levels. This ensured that internal temperatures were never 'dangerously' low, and allowed occupants to choose their preferred temperature. However, some staff reported that the heating was still on during hot summer days, making buildings uncomfortably warm. This possibly reflects confusion about who is responsible for operating the heating, and some occupants being incapable of accessing or operating the heating controls.

The residents' interaction with heating controls varied depending on the resident themselves, as well as the care setting they were in. In the residential care homes, the heating controls were operated by staff, while in the extra care settings, residents were expected to manage the controls within their own flats, although, as previously discussed, they were persuaded not to interact with the heating controls in the communal areas. However, some residents in the extra care settings lacked the physical abilities to do this, and reported that if they needed the heating settings changed, they asked a staff member to do it for them. This could pose significant issues in the extra care setting, as staff are not necessarily around at all times to help. In case study D, where there were more complex heating controls, the residents reported that they generally left them alone and did not alter the settings often, if at all.

Coping with heatwaves

All onsite care managers interviewed for this study were aware of the PHE Heatwave Plan, although managers interviewed for the *Conditioning demand* study were unaware of it. During the hot weather that affected the UK in June/July 2015, which triggered a Met Office-issued level 2 heat-health alert, all onsite managers received emails from senior managers or local authority commissioners, forwarded on from PHE. The extra care housing scheme managers summarised some PHE recommendations in leaflets and circulated these among staff and occupants.

In contrast, no carers in the residential schemes interviewed for this study were aware of the PHE Heatwave Plan, although most demonstrated awareness of measures that could be taken in particularly hot weather.

No case study site had its own heatwave plan. Rather, managers reported that they implemented some aspects of the PHE Heatwave Plan on an *ad hoc* basis. Measures taken included checking that residents drank sufficient water and wore appropriate clothing. Carers also took steps to reduce the temperature within buildings by opening windows or external doors, and by closing blinds or curtains to minimise heat gain from sunlight (Figure 23). One manager also said that they checked that the heating was turned down in occupants' rooms. Several interviewees mentioned the use of electric fans in hot weather (Figure 24), although in some cases occupants or their families were expected to provide these. Some carers also said that they might take occupants to cooler parts of the building, or outdoors, in order to cool down. Several interviewees emphasised the importance of ensuring that older occupants wore sunhats and were kept out of direct sunlight while outside.

Figure 23: Curtains closed during the daytime to shade the room from direct sunlight

Figure 24: Occupants reported that they often used electric fans during summer months

Onsite managers and carers identified barriers to the implementation of some aspects of the PHE Heatwave Plan. Ingrained social and managerial practices created particular challenges. Across the case studies there was apparently little variation in the food served to occupants between winter and summer, and one manager justified this saying, “the residents here do expect […] a hot meal at lunchtime”. Some residents were reported to wear the same type of clothing throughout the year. Managers and carers claimed that occupants who received care were able to take additional showers in hot weather, but that few chose to do so, with one manager characterising the attitude of some residents as, “I only get a bath on a Monday once a week and I ain't straying from that”.

Some occupants' physical conditions also presented barriers to the uptake of PHE recommendations. One manager observed that some occupants do not like to drink more water than usual, as this causes them to require the toilet more frequently, and incontinence and mobility impairments can then lead to 'accidents'. Several interviewees noted that few older occupants like to spend time outside during the summer owing to some occupants' concerns about becoming too hot or need for "special chairs".

Managers questioned some of the advice featured in the PHE Heatwave Plan. All managers reported that they had never required additional care staff during hot weather. Some managers suggested there would be practical difficulties in creating 'cool rooms' owing to a lack of suitable rooms, and because of the difficulties of moving all occupants into one room.

No managers had consulted individual occupants' GPs about the potential health risks from heatwaves. Only one care home manager reported having a good understanding of which occupants were at greatest risk from heatwaves, suggesting that individuals who were incapable of making or enacting their own decisions, or occupants with medical conditions such as respiratory problems or cardiac problems, were regarded as particularly vulnerable. By contrast, one extra care scheme manager argued that all occupants were equally vulnerable. Another extra care scheme manager suggested that as the housing scheme provided "independent living", it was up to individual residents to follow their GP's advice on the potential health risks posed by heatwaves.

Lack of structural investment

Onsite managers and carers identified ways in which building design, combined with social practices, limit natural ventilation. Interviewees who worked in extra care housing observed that it was often difficult to achieve through ventilation, partly because most apartments were single aspect with windows on one side of the dwelling only, and partly because occupants were often reluctant to leave their apartment front doors open due to concerns about theft and intrusion by people with dementia. Restricted window-opening, intended to prevent occupants from falling through open windows, limited ventilation in all cases. Interviewees reported that window-opening was further constrained by some occupants' objections to draughts or fears that insects would get into the building, or by security concerns. Windows in communal areas in all cases were routinely closed at night to prevent intrusion, but occupants were generally permitted to leave windows open overnight in their own rooms or apartments.

In extra care housing the installation of blinds and curtains was the occupants' responsibility. Interviewees observed that it was generally unfeasible to leave blinds or curtains closed during the day where rooms were occupied, as occupants need access to daylight and views out. Subsequently blinds were generally kept closed only in rooms unoccupied during the day, such as individual bedrooms in care homes once occupants had gone to communal rooms, and only in extremely hot weather.

Residents' experiences and expectations

Residents had differing views on whether they found their homes thermally comfortable in summer, and what constituted a comfortable temperature. This could lead to disagreements and conflict. Windows and heating controls in communal areas were a particular source of friction in the extra care setting. For example, residents who opened corridor windows reported that someone else closed them soon afterwards.

Some occupants reported that they were generally comfortable, although some noted that in hot weather it could be difficult to sleep or that they had to use electric fans. Four of the ten interviewees, who were fitter and more active, reported that their homes were too warm in summer, observing that, "it gets extremely warm in here, too uncomfortable" and, "it's like sitting in a greenhouse".

While some care and extra care residents controlled their own heating (seven of the ten interviewees), others were incapable of doing so owing to physical or cognitive impairments (particularly in the residential care homes). The latter relied on relatives or carers to set or alter thermostats and timers. However, there could be disagreements about indoor temperatures between residents, their relatives and scheme managers; while some occupants complained that their building was too hot, their relatives or scheme managers argued that older people needed to be in warm environments. While some occupants with greater care needs liked living in a warm building, relatively active occupants were generally resistant to the idea that older people need to be kept warm throughout the year. One extra care resident was annoyed that in the communal restaurant, “they've got the flippin' heating on” in summer months for the “old people”.

While some occupants had some control over ventilation, physical impairments impeded some residents’ ability to open windows and patio doors (three of the ten interviewees). Residents noted that restricted window-opening limits ventilation and that it was difficult to achieve through ventilation (confirming comments from carers and management interviewees). For some, this problem was compounded by concerns that leaving the door to their room/apartment open would lead to intrusion by thieves or people with dementia. Window-opening was further constrained by concerns about hay fever, or intrusion by cats or insects.

Issues with the building and services also affected the ability of residents to control their thermal comfort in hot weather, including a lack of awareness of and use of trickle vents; a reluctance to close blinds or curtains during the day to reduce heat from sunlight, as it made them feel ‘shut in’ and they missed the view; and the need to keep the heating on throughout the year due to issues with airlocks in the underfloor pipework.

Generally, the residents’ comments concurred with the staff’s responses regarding habits, routines and daily practices; for example, several residents in extra care housing reported that they prepared their own food and ate a cooked meal every day, consequently using their oven daily, even in summer. Some occupants said they varied their clothing throughout the year, while others wore the same types of clothing throughout. Two occupants in extra care housing reported that they took more showers in summer than in winter, but explained this was primarily to remove sweat rather than to cool down.

Summary

In the interviews with designers and asset managers, it was apparent that the mitigation of the overheating risk was not seen as a priority within the design and commissioning of care schemes. Awareness of how to reduce such risks, and the implementation of design measures to ensure building resilience to both current and future climate change, was relatively low.

There was also evidence of a disconnect between design intent and actual management of systems, due, in part, to the procurement routes used for such schemes and the complex management structures in care organisations.

The health risks to older residents from heatwaves were not a major concern for managers and care staff. None of the managers or carers interviewed for the study had experienced a heat-related emergency. Heatwaves were regarded as rare, and cold was seen as a bigger threat to older residents’ health than heat. These views were reflected in *ad hoc* compliance with only some recommendations of the PHE Heatwave Plan, such as those relating to occupants’ fluid intake and clothing levels; an apparent lack of structural investment in building features that would improve natural ventilation and minimise solar heat gain; and the confusion over who was responsible for controlling heating systems. The latter led to circumstances where the heating was found to be on during hot weather, adding directly to overheating problems.

Residents and care staff interviewed for the study had diverse views on thermal comfort, but some reported that during summer months they often felt too hot, suggesting that heat management is poor in some cases, and highlighting the difficulty of catering for occupants’ diverse needs and preferences.

While some occupants felt uncomfortably warm while at home during summer months, few occupants regarded high temperatures as a potential health risk. Similarly, few onsite managers or carers seemed aware of which residents might be particularly vulnerable in heatwaves, or how certain underlying health conditions can be exacerbated by heat.

7 Building resilience against overheating and heatwaves

This chapter considers the overall goal of building resilience to overheating and heatwave risks, the challenges involved, and the types of specific measure that could be taken in the four case study care settings to reduce the risk of overheating.

Adaptation and resilience

Adaptation and resilience are often multidimensional in character (see Box 3). Care sector adaptations for higher summer temperatures can take the form of both short-term responses during heatwave periods (when risks are acute and particularly concentrated in time, for example to alter daily working practices in the care setting), and the longer-term development and implementation of design and physical measures to reduce building overheating risks, so that internal temperatures do not reach dangerous levels during heatwaves. The relationship between 'emergency' heatwave conditions and being resilient to these, and more general patterns of summertime 'overheating' is not entirely straightforward. Ideally, though, there should be complementarity in any actions taken between physical building-related measures and those related to management and care practices.

Box 3: What is adaptation and resilience?

Resilience: "the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, and the capacity to adapt to stress and change".

Adaptation: "an adjustment or a change in the way things are done in response to climate variability and its effects or those expected to occur in the future (climate change projections). Adaptation is primarily used to describe adjustments that either reduce the impact of these events or exploits the beneficial opportunities they bring. There are many different ways of categorising adaptation – some of the most common are planned, spontaneous and anticipatory".

Source: UKCP09, 2014

Neither design measures nor ongoing management and care practice changes can be sufficient responses on their own. Design measures cannot necessarily be fully protective of vulnerable residents during significant heatwaves, and even with much policy impetus they are likely to appear relatively slowly across the building sector, given the inertia in new-build and retrofit processes. Design features such as shading devices and ventilation systems also need to be understood and used well in order to be effective.

Similarly, better management and care practices during heatwaves cannot fully compensate for badly designed and/or seriously overheating buildings; and while, in theory, practices should be easier to shift relatively rapidly, in reality there can also be much inertia in established management approaches, routines of operation and habitual behaviours. To complicate the challenge further, there is also great diversity across the care sector in terms of institutional and organisational structures; the age, forms and conditions of the buildings involved; and the management arrangements and responsibilities for fundamental aspects such as heating.

Regardless of the challenges involved, though, the aim of becoming more resilient to overheating and heatwave risks in the care sector should be to ensure that no additional ('excess') mortality or morbidity occurs during future heatwaves. Given that vulnerable residents are within settings that should be providing care, and therefore protection, against thermal risks – as they already do against cold weather conditions – this is a reasonable aim, and both building design and ongoing management and care practices need to become better focused towards this goal.

Adapting management and care practices

The management of care and extra care settings can be very demanding and involved, as can working as a member of the care staff and wider organisational team. There are many different competing pressures and concerns, from regulatory requirements, business pressures, and the needs, expectations and demands of residents and their relatives. These pressures were evident across the case studies.

The study universally found little awareness or concern about thermal risks (now and in the future) among those involved in management and care roles. Given this, an overarching need for improving resilience in the care sector is to radically extend both awareness and understanding of heat-related risks for older people among all of those involved in the provision of care. This needs to include understanding that:

- there is a difference between pleasant summertime warmth and sunshine, and heatwave periods that can have serious impacts on health. The transition into a heatwave period therefore necessarily entails 'non-normal' conditions and responses in which significant disruption to routines and priorities should be expected, although for a relatively short period;
- vulnerability to heat is generally focused on older people, but specifically on those with particular health conditions. This differential susceptibility needs to be understood, identified among residents in care settings, prepared for and responded to;
- while keeping older people warm is important for their health, the general culture of seeing the cold as dangerous, and warmth as good, can become a problem if it dominates over understanding the health risks inherent within significantly higher and extended heatwave temperatures; and
- while significant heatwaves have been rare to-date in the UK, this is expected to change, with the heatwave of 2003 expected to be a more frequent occurrence by the 2050s. Therefore what is understood as 'normal' now is not a good guide to what may come in the future. Being prepared for that different future is important, as is being prepared for the growth in the older population over the coming decades.

In terms of the specific preparedness that needs to be developed and the actions that can be taken before and during heatwave periods, the current PHE Heatwave Plan guidance for those in the care sector contains many appropriate provisions. Chapter 8 of this report provides recommendations for aspects that are not as well covered, or are in need of strengthening.

What is crucial, though, is that the provisions of the Heatwave Plan are extended into the actual and ongoing work of all of those involved. While some awareness was found at a management level in the four case studies, this awareness did not extend across other interviewees (such as onsite care staff), and the impression is that measures to keep residents cooler and address the risks involved are undertaken in a rather *ad hoc* manner, if at all. Improved resilience in this respect could involve a range of measures including local site-specific heatwave plans, training programmes, and including heat-related health vulnerabilities in care plans. Some aspects of planning for resilience that are in need of strengthening relate specifically to how management and care practices interact with features of the building and its thermal technologies, and given the additional focus of the work on design, there are specific aspects to be highlighted:

- It is particularly important that internal heat gains are minimised during heatwaves. Most fundamental, if rather counterintuitive, is to ensure that the heating system is completely switched off, to reduce circulation of hot water through the heating system. Communal heating and hot water systems need to be carefully considered at the design stage due to such effects, along with the building occupants' hot water requirements throughout the year.
- As part of raising awareness about heatwaves and summertime thermal comfort more generally, all staff should be educated about solar gain impact, internal gains from heating systems, and ventilation. This will require training in how to operate heating systems, shading devices (internal or external), and ventilation systems seasonally. For extra care homes, regular education could extend to the residents – possibly through yearly sessions, as part of managers' engagement with their residents, as well as informally in residential care settings.

- Understanding how building orientation relates to heat risks can guide where to place certain individuals based on vulnerability. As an example, north, east and north-east facing bedrooms were found to overheat less, so more vulnerable or bed-bound residents should be placed in these rooms. It is, however, understood that there are other factors limiting resident placement.
- As an additional task, care staff may be expected to operate shading elements (e.g. open shutters), and open and close windows for ventilation. This can be considered a part of caring for the resident, as thermal comfort has an impact on health.

Design-related adaptation and remedial measures

To appraise technically feasible and acceptable remedial options (physical) for building resilience across different care settings, dynamic thermal simulation was used. Specific solutions were identified for each site, and these are outlined in separate case study reports. Design methods for passively cooling dwellings can be summarised in three key principles (Gupta and Gregg, 2012):

- Reduce external temperatures by managing the microclimate (non-fabric changes such as use of trees and vegetation to provide shading).
- Exclude or minimise the effect of direct or indirect solar radiation into the home (fabric changes such as fixed louvres, external shutters and overhanging eaves).
- Limit or control heat within the building (e.g. reduced internal gains or managed heat with mass), including through ventilation.

The following are important to note when considering how to apply adaptation measures to mitigate overheating:

- Adaptation measures may not be universally effective, i.e. many existing conditions of buildings cause the results to vary widely.
- Measures may not be universally effective even at the building level, i.e. bedrooms can respond differently than offices, etc.
- In some cases, measures that are effective for long-term overheating (as assessed through either the adaptive or static methods) may not be effective during heatwaves, and vice versa.

Modelling appropriate physical measures for the case studies

The most effective passive adaptation options for the four case studies included shading (e.g. with shutters), reflective roofing materials, thermal mass (only where applicable), and, in some instances, interior blinds. While all key rooms have been evaluated (see separate case study reports), for illustration, Figure 25 shows the effectiveness of three single adaptation measures for all four case studies' lounges in the 2080s climate period using the static method. Shutters are most effective for two case studies, but case studies B and C are more responsive to other options (triple glazing and reflective roof finish). Generally, single adaptation measures were not enough to reduce the overheating risk completely in the rooms simulated (residential, communal and office), and packages of measures are required, although combining measures is not necessarily a linear relationship. In some instances, by the 2080s climate period no (tested) combination of passive measures was effective in eliminating overheating, e.g. case study C lounge (Figure 26).

Figure 25: Most effective single passive adaptation measures for the case studies' lounges

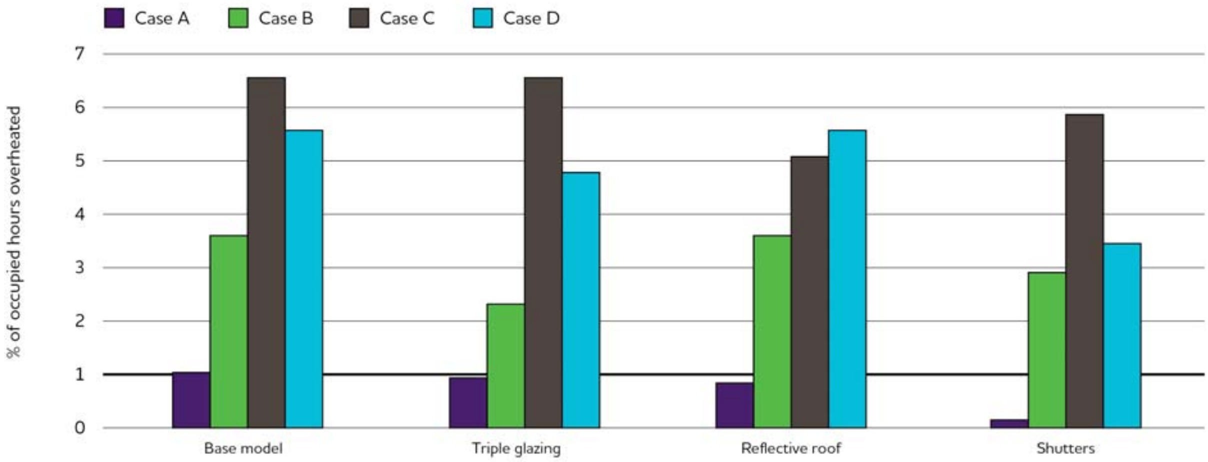
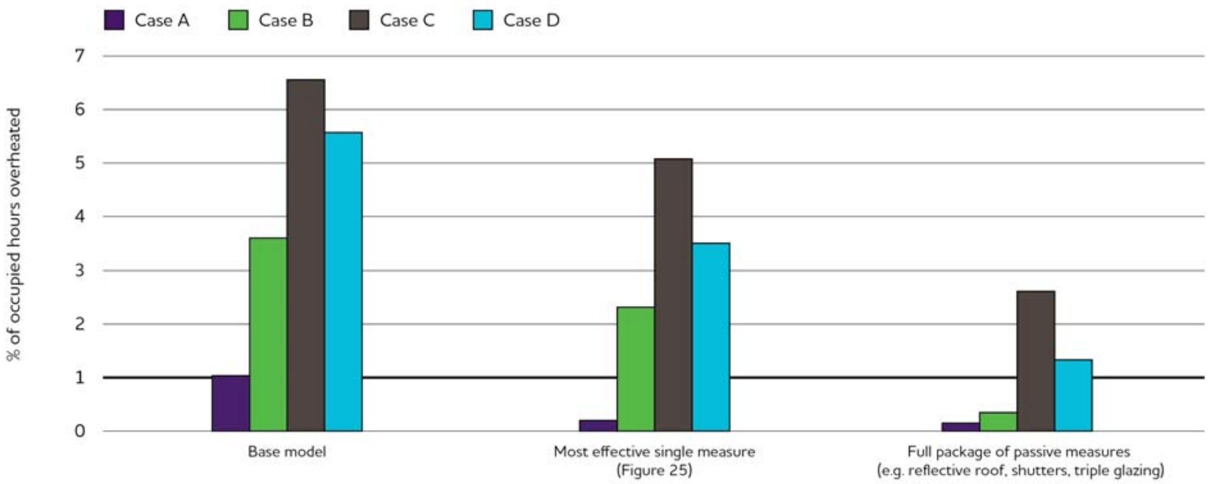


Figure 26: Impact of packages of passive measures on overheating risk in case study lounges in 2080s



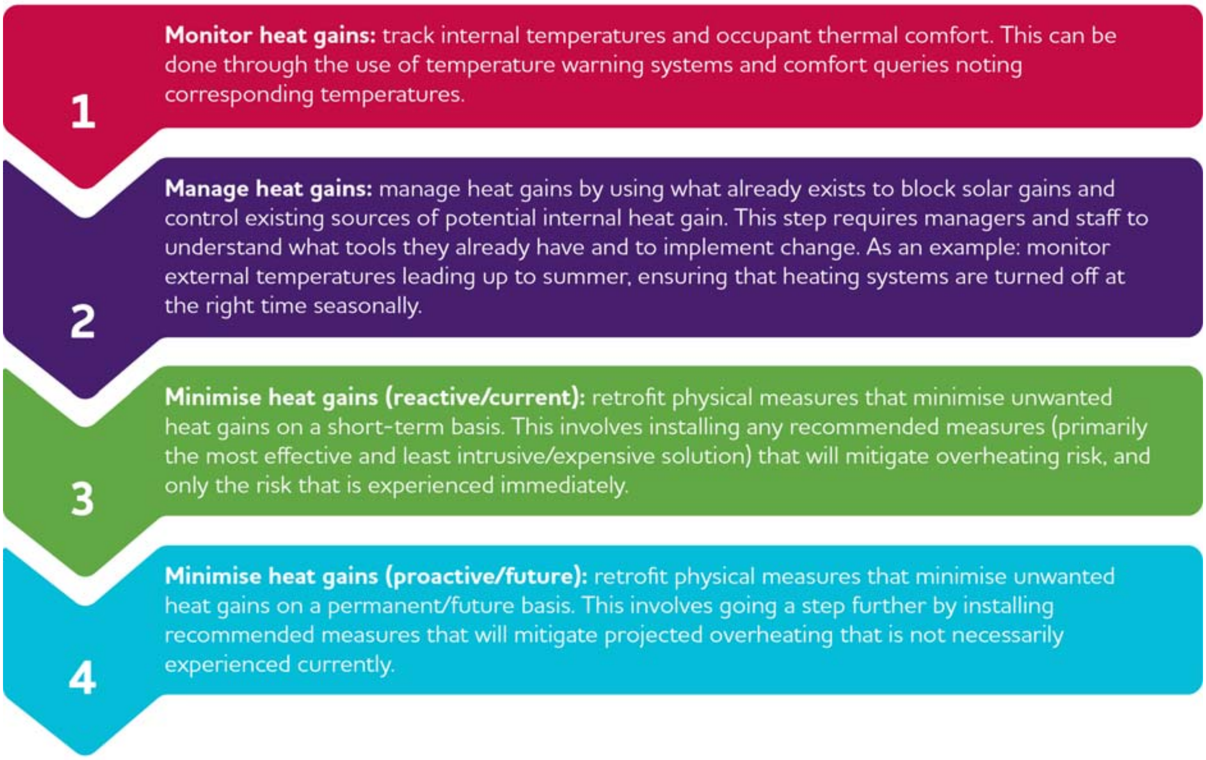
Management of natural ventilation (ventilation dependent on external conditions) can be either passive or active, depending on how it is controlled. In some cases, appropriate natural ventilation management (in this study, closing windows when the external temperature is >25°C) is effective alone in eliminating overheating risk. Intelligent natural ventilation management will require carers, building managers or building management systems to be involved in temperature monitoring, and window-opening and closing management or supervision. As buildings and spaces are very different in how they heat up, e.g. due to solar orientation, the temperature at which natural ventilation through windows needs to be managed can vary widely.

Ceiling fans also provide an effective, low energy and inexpensive active measure. As an example, in a case study A first floor bedroom, for all hours when the temperature is above 25.5°C between 7pm and 7am, fan energy use can range between 0.9-1.8 kWh (depending on fan selection) for the entire summer. However, for case study C the internal temperature is too high for increased air velocity to improve thermal comfort. Again, integrating more measures would be helpful. The measures could be phased in over time, however, as noted from the monitoring findings, the summer of 2015 has demonstrated overheating and heatwave results similar to those projected for the 2050s and beyond. For this reason it may be suggested that individual measures (or even entire packages – see Figure 26) are more immediately installed; however step-by-step installation will allow observation of the impact over time. Simpler measures like ceiling fans can be installed and tested in willing occupants' rooms.

Packages of adaptation measures (for care and extra care settings)

Considering the effort, potential cost and impact of recommendations, the following plan of action is recommended (Figure 27), integrating both physical and behavioural/practice measures in existing care/extra care homes. Impact should be monitored as progress is made.

Figure 27: Recommended plan of action for overheating risk mitigation and adaptation strategies



The differentiation in recommendations between care and extra care settings is most apparent in management and care practice adaptation. One specific differentiation is in the capability of the occupant. In care homes, often less can be expected of the residents, and more intervention and understanding of conditions, health and impact of heat will be needed from the management and care staff.

Summary

The distinction and relationship between heatwave conditions and being resilient to these, and more general patterns of overheating, is not entirely straightforward. Ideally there should be complementarity between physical building-related measures and those related to management and care practices.

Neither design nor ongoing management and care are deemed sufficient responses on their own – instead a holistic approach considering all these aspects is needed.

An overarching need to improve resilience in the care sector is therefore to radically extend both awareness and understanding of heat-related risks for older people among all of those involved in the provision of care. Steps could include local site-specific heatwave plans, training programmes, and including heat-related health vulnerabilities in care plans.

The most effective single passive measure across all case studies is external shading, i.e. shutters. However, in some instances, by the 2080s climate period no tested combination of passive measures was effective in eliminating overheating, particularly in case studies C and D. By the 2050s, passive strategies for tackling overheating are likely to be necessary for the case studies in the south of England. By the 2080s, passive strategies for tackling overheating are likely to be necessary for care/extra homes across the UK. Measures that mitigate overheating risk or enhance resilience will need to be tailored to each building's construction and location, and each individual space's orientation and occupancy pattern. Consideration could be given to avoid locating residents with particular vulnerabilities in hotter rooms. Some measures like shutters may also require occupant interaction.

Based on observed weather, it is possible that individual measures or entire adaptation packages will be needed more immediately than the 2050s or beyond, and should therefore be installed at the next possible opportunity.

Staff and resident training on how to adapt daily routines to support action on overheating can be implemented much sooner, and should include a focus on understanding and managing heating controls, and clarifying responsibilities to make adjustments when needed.

8 Findings and recommendations

The key findings are set out below. The emerging recommendations were discussed and informed by a workshop held in December 2015, with participation from policy-makers, care providers, practitioners from design and management of care homes, as well as experts in overheating in buildings.

Key findings

The following outlines the key findings. It must be noted that these are based on only a small number of case studies, and therefore further studies are recommended to validate the conclusions.

General culture and perceptions

Care schemes have a culture of 'keeping residents warm'; there is a perception that older people are vulnerable to cold, not heat.

- Throughout the study, there was a prevalent perception that older people 'like the heat' and 'feel the cold', and that cold represents a bigger threat than heat to older occupants' health. While the cold is still a more prevalent health risk, there is less recognition that heat can also present a significant current health risk, which is only set to increase.
- The perception of older people 'feeling the cold' also does not necessarily reflect the findings within the study, which suggested that people's own perceptions of their thermal comfort vary significantly.
- This conceptualisation of older people as 'cold' is reinforced by current regulatory practices in terms of the provision of warmth being associated with good care, and appears to blind people within the care sector to the risks of both short-term periods of hot weather, and long-term increases in temperature.
- There is thus a strong culture in which the cold is considered dangerous, warmth is related to good care, and excessive heat is tolerated as a choice of residents.

There is a lack of awareness of overheating risks.

- There was a general lack of awareness of the impacts of overheating, and the prevalence of the overheating risk both now and in the future across all those involved. This appears to be, in part, due to the 'warmth culture', as well as a relatively lax attitude, particularly among onsite care staff and residents, towards heatwaves. These are seen as something that only occur rarely in the UK, and as such can be managed through short-term adaptation practices such as the use of mobile electric fans.

Experience of overheating

There is a mismatch between the results of climate modelling and environmental monitoring, which underplays the current risks of overheating.

- Monitoring in the summer of 2015 revealed incidences of short-term heatwaves externally in two of the case study locations, as well as cases of overheating in some rooms across all four of the schemes, even during non-heatwave summer periods.
- In contrast, the climate change modelling of the four case study schemes indicated only limited overheating risks until the 2050s. Although there are modelling uncertainties (such as the fact that weather files used for climate change modelling represent average weather, and 2015 could have been a warmer than average summer), climate modelling indicates that overheating is still only a future risk, whereas empirical monitoring data suggests it is a current and prevalent risk that can only worsen if external temperatures are to increase as climate change research indicates.

Design and delivery

There is a lack of prioritisation of summer overheating risk and future climate change in the design of care schemes.

- Planning for future overheating was not perceived to be 'top of the agenda', as care and housing providers tend to plan for the near future, rather than the longer term. They do not anticipate the effects of climate change to be large enough to impact upon operations within the next 30 years or so – the lifespan for which buildings tend to cater before restructuring is required for changes in care needs.
- Design briefs for the case study buildings prioritised other design requirements and needs over overheating risk, in particular cost, care requirements, and health and safety of staff and residents. For example, window restrictors are put in place to reduce the likelihood of falls, but reduce the occupants' ability to ventilate and cool their space. In addition, the spatial requirements of care facilities are often prioritised, and subsequently conflict with passive ventilation strategies. Innovative approaches are available, but are not yet mainstream within the design sector.
- The case studies had few external solar shading devices, relying instead on less effective internal shading devices. However, in extra care housing, the installation of blinds/curtains was regarded as the residents' (or their families') responsibility. Furthermore, keeping blinds closed during the day is feasible only in rooms unoccupied then, as occupants need to see out and have access to daylight.
- Overheating, although considered an issue that is addressed by 'overall good, environmentally-sound design', was not felt to be widely understood within the design sector, and design for overheating is not commonplace. In part this is due to regulatory and cultural notions surrounding the provision of heat in the care sector. Where solutions are considered, they are often compromised due to other priorities such as practical, spatial and care requirements.

Differing overheating, thermal comfort and health-related thresholds can hinder addressing the risks for care settings.

- Environmental and energy modelling software enables designers to model overheating risk. However, the guidance in terms of assessing overheating provided in the building sector is more specifically related to thermal comfort rather than heat-related health risks, and there is a lack of clear regulatory requirements in relation to addressing overheating in the care sector.
- The adaptive method was developed in non-domestic testing sites and suggests that the occupant can adapt to higher internal temperatures when the external temperature is higher. However, as previous research suggests, the residents of care homes are likely to be vulnerable to heat and this method may not be stringent enough for such highly sensitive individuals.
- There is some overlap between static threshold temperatures in the building sector guidance, such as CIBSE Guide A, and the health-related guidance, such as PHE's Heatwave Plan. However, the lack of an evidence base specific to the care sector and elderly persons, and consistency in overheating thresholds, can lead to confusion and a lack of understanding of how to define overheating, and when and where heat-related health risks are occurring. Fundamentally, it prevents the development and implementation of long-term resilience and adaptation strategies in the care sector to both combat heat-related illness and death, and improve thermal comfort during periods of hot weather.

There is a disconnect between designers and end users, and a lack of communication from design intent to handover and use of buildings.

- Due to common procurement methods for new buildings that use a single main contractor to undertake all aspects of the work (who may appoint several disparate subcontractors), the initial designer of a care scheme is often not involved in the ongoing detailed design and specification process. This can lead to decisions, mainly cost-driven, that conflict with the original design intent for the building.
- The study also indicates a lack of communication and 'joined-up' approach from design through to use. As evidenced in case study A, separate consultants were used to design, specify and commission the electrical and mechanical services, but were not fully involved in the handover process, resulting in inadequate communication to the end users about the systems and how to operate them effectively.
- This is particularly relevant in medium-to-large care sector organisations where there are often separate building management and maintenance teams that, as they are responsible for the physical building, receive the handover from the main contractor (rather than the actual onsite end users).

This results in a lack of agency among onsite care staff in operating heating controls and the management of heat.

Managing care homes

There is a lack of long-term infrastructure to enable effective heat management.

- While all schemes in the project used a wide range of measures to deal with the heat, this was often on an *ad hoc* basis. Structural, long-term investment in keeping cool was often lacking and not prioritised.
- Where overheating is discovered, post-construction, 'quick-fix' approaches such as localised mobile electric fans are used, rather than reviewing long-term strategies.

Separation of roles within care organisations leads to confusion and a lack of understanding of roles and responsibilities in relation to heat management.

- Use of centralised heating systems controlled offsite can mean that the responsibility for heat management is removed from the daily users (care staff and residents). It can also restrict the potential for management of heating systems and strategies to be communicated to the appropriate staff and users.
- The care sector often has a high turnover of staff, which can result in further confusion about how the heating and ventilation systems work and whose responsibility they are. This can lead to contradictory actions, like staff opening windows when the the radiators are on.
- Communal heating systems can enable centralised control, but localised requirements (e.g. hot water) mean that heating systems are in operation during the summer, contributing to the overheating of the building (in both care and extra care settings).

A lack of awareness and practical issues hinder full application of the PHE Heatwave Plan.

- All of the onsite managers interviewed in the present study were aware of the PHE Heatwave Plan, which offers guidance on how to prepare and respond to periods of hot weather, specifically heatwaves.
- Most care staff interviewed were unaware of the Heatwave Plan. Despite this, staff in the case studies did demonstrate an understanding of the immediate measures required.
- A lack of visible feedback on actual temperatures (rather than temperatures perceived by the staff) is likely to make the implementation of appropriate measures, at the right time, difficult; particularly as effective measures to keep people and buildings cool, and identifying those at risk, requires forethought and preparation.
- While the Heatwave Plan seems sensible, practical and comprehensive, implementation can be difficult in practice if the advice does not fit in with the everyday routines and practices within care schemes, as well as the physical condition and thermal comfort perceptions of residents. Managers reported practical difficulties in terms of creating 'cool rooms', and none had consulted individual occupants' GPs about potential health risks from heatwaves.

Caring and living practices

Occupant expectations and control requirements vary.

- There is huge diversity among the views of occupants on their personal thermal comfort.
- Often residents of care homes are reliant on staff to provide thermal comfort, while dependency varies significantly in the extra care setting. Particularly in the communal areas, there can be a conflict between what the residents choose to do, and what is best for their health and comfort, especially in residents with dementia. As dementia is likely to become increasingly common, the balance between providing accessible, and user-operable and automated controls is becoming more critical.
- Staff members also have issues with heat; they tend to be more physically active and, combined with a culture of 'having to put up with it' as it is 'their [the residents'] home', this leads to a potentially hazardous work environment, particularly during heatwaves when the workload increases further.

Engrained habits, practices and the abilities of carers and residents can hinder risk management.

- Since being too hot can induce drowsiness and lethargy, some residents may not be able to complain about the heat in the same way as they can about the cold.
- Engrained routines can contribute towards vulnerability to heatwaves, due to an inflexibility to adapt to short-term changes in habits and daily practices.
- Much of the focus of carers, in terms of ensuring well-being in the residents during hot periods, is on preventing dehydration, and not necessarily addressing the main health risks, such as heat exacerbating heart and respiratory diseases.

Recommendations for practitioners, policy-makers and regulators

Table 18: Recommendations for national policy-makers and practitioners

Recommendation	Key stakeholders
Challenge the culture of warmth and increase awareness of the current and short-term future risks of climate change and overheating in the care sector; promote best practice in terms of both design and management measures that enable resilience and future adaptation.	DoH; PHE; CQC; care providers; design, commissioning and development teams

Table 19: Recommendations for national policy-makers

Recommendation	Key stakeholders
Develop more detailed national guidance on monitoring and minimising the overheating risk in the care sector.	DoH, PHE with others
The PHE Heatwave Plan guidance should be strengthened and added to in a number of ways: • Recommend (at level 0) the development of a local site-specific heatwave plan, which is then embedded into management practices and staff induction and training. Provide guidance on training required. • Add a first key step (at level 2) that all heating systems are completely turned off, so that the amount of heat being added internally is minimised. This will need to be clear about how this is done, and whose responsibility it is to switch off the system. • Consider whether the recommendations on the creation of 'cool rooms' are likely to be feasible in practice for certain configurations of care/extra care homes. Further discussion should be had in terms of how to provide 'cool areas' in a practical and feasible way. • Include guidance on an overheating detection protocol, using smart sensors and based on harmonised overheating thresholds, preferably with stepped warnings relating to thermal comfort as well as health-related temperatures.	DoH, PHE with others
Develop and implement an overheating detection protocol for raising awareness and early identification of the risk of overheating using smart sensors and surveys during summer months in buildings with vulnerable occupants, and promote this in the Heatwave Plan.	PHE, DoH; CQC; other governmental bodies working in the care sector
Collaborate to harmonise and standardise health-related and building thermal comfort-related overheating thresholds, with particular consideration of care settings. A cross-departmental/professional body/working group would be beneficial.	CIBSE; DCLG; PHE; DoH, DEFRA, CQC
Investigate and incorporate standardised overheating thresholds and/or criteria, relating to both health and thermal comfort, into Building Regulations and specific guidance relating to care sector developments, where practically possible.	CIBSE; DCLG; DoH; PHE
CQC should consider preparedness for climate change as a health risk within the care sector, and how its policies and procedures address this risk. Consider integrating criteria on preparedness for current and future overheating, and other risks posed by climate change, and the practical implementation of the Heatwave Plan for England into care sector inspection arrangements.	CQC; PHE; DoH
Commissioning further research (particularly long-term monitoring) into thermal comfort, excess heat related deaths and relative temperatures (internal and external) in buildings in the care sector is critical to: • provide evidence on the scale of the problem; • Improve take-up of guidance; and • identify heat-related health risks, as well as thermal discomfort during current and future hot summer months.	DoH; PHE; CQC
Share insights from case studies where heatwaves have been experienced and tackled with those involved in the design, management and use of care homes.	DoH; PHE; CQC

Table 20: Recommendations for practitioners

Recommendation	Key stakeholders
Improve resilience and promote awareness of overheating in the care sector by: • monitoring for and minimising overheating risk; • adopting localised heatwave plans, which apply PHE's guidance with a series of actions for the local site setting, considering both short-term responses to working practices and longer-term solutions; and • instituting ongoing briefings and training for onsite care managers, staff and residents (particularly in extra care setting), to address the management of overheating risk both generally and within their specific setting.	Local authorities; care providers; care managers and staff; residents; PHE
Support communication and greater clarity on the roles and responsibilities of differing staff and residents in heatwaves, in terms of the operation of heating and ventilation systems in care homes and other care facilities.	Local authorities; care providers; care management maintenance team; care managers and carers; residents
Promote design to minimise overheating by ensuring that designs of care facilities tackle current and future risks of overheating, e.g. considering location and orientation carefully, and promoting passive building design solutions such as ventilation, shading and thermal mass, to avoid future overheating problems.	Design team; development team (commissioners of care settings)
Ensure climate modelling of new care settings is undertaken in relation to the overheating risk using dynamic thermal simulation. Since future weather files represent average weather (although work is ongoing by CIBSE to address this), it is recommended that extreme scenarios are used, such as high emissions and 90% probability, so that care settings can withstand current and future overheating risk.	Designers; development team
Develop physical measures that adapt care settings in the short, medium and longer term (preferably up to a 60-year period). Ensure that these measures are also robust enough to anticipate and work with other priorities of building in the care sector, such as health, safety, security and finance.	Development team; designers; construction team
Ensure there is a 'joined-up' approach to design, installation and commissioning of services, systems and controls, particularly in relation to communal heating and ventilation, to avoid unwanted heat gains and enable effective heat management.	Development team; designers; construction team; maintenance team
Promote monitoring of local (external and internal) temperatures to identify risk of overheating and promote early preparations such as, where appropriate, opening of windows during the night to allow night cooling prior to heatwave period, as well as operation of shutters during the day.	Development team; maintenance team; care managers; carers
Consultation with residents' GPs and/or nursing staff, to assess the health risks posed by extreme heat for older residents and those on medication.	Care managers; carers
Training and education programmes for care managers, carers and residents, to enable them to adjust routine ways of running the care setting during a heatwave.	Care managers; carers; residents

Summary

This study has provided valuable evidence on the risks and experiences of overheating in both care and extra care settings, now and in the future. This is particularly vital, as there is currently little research on heat management, overheating and thermal comfort in these settings, specifically during the summer months. Such research is essential if adequate facilities are to be provided and maintained for an ageing and subsequently vulnerable population facing climate change in the UK.

The findings and recommendations suggest that overheating is both a current and future risk in care schemes, yet there is currently little awareness or evidence of long-term strategies to provide suitable adaptation methods and increase resilience within the sector. While many of the adaptation strategies require input from designers, commissioners of care services, and care home managers and care staff, support is required in terms of enhanced and focused regulations, standards and guidance from key care sector bodies, and government departments such as CQC, PHE, DoH and DEFRA. This is also important as a future risk consideration for the UK Climate Change Risk Assessment and next National Adaptation Programme. Perhaps most urgently, there needs to be a culture change within the care sector itself in order to ensure 'keeping cool' (using passive measures) is prioritised as much as 'keeping warm'.

Notes

1. Conditioning Demand was a two and a half year study (January 2011 to June 2013) funded by the Research Councils UK Energy Programme and ECLEER, and led by University of Manchester in collaboration with the University of Exeter, Cardiff University, Lancaster University and EDF Research & Development. It sought to understand the diversity and dynamics of thermal experiences in an ageing society, and the subsequent implications for current and future energy consumption. The secondary analysis included in this report focuses specifically on learnings from the study relating to overheating and future climate change adaptation. See http://www.seed.manchester.ac.uk/marc/research/projects/past-projects/2013/conditioning-demand/

2. PROMETHEUS was a 30-month project led by the University of Exeter that aimed to develop a new set of probabilistic reference years (up to 2080) that can be understood and used by building designers. The PROMETHEUS weather files cover over 40 locations across the UK and have been used by leading engineering and architectural firms to test the resilience of their building designs to climate change. Further details can be found at: http://www.arcc-network.org.uk/project-summaries/prometheus/#.VuaGQPmLSWh

3. An effective approach to climate change modelling for the coming century in previous projects, including those under the *Design for Future Climate* (D4FC) programme, simulates three climate periods, generally 2030s, 2050s and 2080s. Central estimate, i.e. 50% probability, was also a commonly used probability in D4FC projects. High emissions scenario (known as IPCC SRES A1FI) is an emissions scenario path roughly being currently followed given the current CO_2 emissions and global economic, technical and social trajectory (Innovate UK, 2015; Gupta *et al.*, 2015).

Glossary

Adaptation: adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Cardiovascular disease: conditions relating to the heart that involve narrowing or blocked blood vessels, as well as affecting the heart's muscle, valves or rhythm. Such conditions can lead to heart attacks, chest pain (angina) and strokes.

Design and build: a building construction procurement route in which the main contractor is appointed to both design and construct the works. Usually the main contractor then appoints sub-contractors, which limits the level of direct engagement that the client has with the sub-contractors. It is different to the traditional procurement route where the client directly appoints consultants to design the scheme and the contractor is appointed to construct the works.

Electrolyte balance: maintenance of salts and minerals such as sodium, calcium and potassium within the body, to help your body's blood chemistry, muscle action and other processes.

Epidemiological: relating to epidemiology, which is the study of patterns, causes and effects of health and disease conditions within defined groups of people.

Excess morbidity: incidence of disease above the expected mean baseline for that region and period of year.

Excess mortality: deaths above the expected mean baseline for that region and period of year.

Free-running buildings: when buildings are not consuming energy for the purpose of space heating or space cooling. In the UK, buildings are usually free-running in the summer months.

Heat cramps: muscle cramps caused by dehydration and loss of electrolytes (salts and minerals found in the body), often following exercise.

Heat exhaustion: weakness, nausea, vomiting, stomach cramps, dizziness and fainting caused by dehydration and salt depletion in the body. Heat exhaustion, if left untreated, can develop into more serious heatstroke.

Heat-Health Watch Service: for health professionals and emergency planners, it determines certain regional external trigger threshold temperatures. These thresholds vary by region, but an average threshold temperature is 30°C by day and 15°C overnight for at least two consecutive days. These temperatures can have a significant effect on people's health if they last for at least two days and the night in between.

Heat oedema: fluid retention in the body causing affected tissue to swell; it is caused by heat expanding the blood vessels so that body fluids move to body extremities (hands and feet) by gravity.

Heat rash: also referred to as 'prickly heat', this is an itchy rash of small red spots that cause a stinging sensation on the skin.

Heat syncope: dizziness and fainting caused by dehydration, vasodilation (expansion of blood vessels), heart disease and some medications.

Heatstroke: result of prolonged exposure to high temperatures, generally coupled with dehydration, leading to a failure of the body's temperature control system (thermoregulation). Symptoms include an increase in core body temperature, nausea, seizures, disorientation and loss of consciousness.

Heatwave: According to the Met Office, a heatwave is an extended period of hot weather relative to the expected conditions of the area at that time of year. The World Meteorological Organization (WMO) definition of a heatwave is when the daily maximum temperature for more than five consecutive days exceeds the average maximum temperature by 5°C, the normal period being 1961–1990. This is different to the Heat-Health Watch Service in the UK that provides warnings for health professionals and emergency planners and has certain trigger threshold temperatures (see Heat-Health Watch Service).

Mechanical Ventilation and Heat Recovery system (MVHR): a whole-house ventilation system that supplies and extracts air to provide fresh air throughout a building.

Overheating: in this text, it is used to describe situations where the temperature inside care settings becomes uncomfortably or excessively warm, relative to the comfort and health-related thresholds considered.

Passive design: design that eliminates the need for mechanical heating or cooling by using aspects of the local climate and the natural environment to maintain a comfortable temperature within the building. Such designs involve appropriate orientation, layout and materials, as well as optimising daylight, natural ventilation and solar energy.

Pathogen: an infectious biological agent that causes disease or illness to its host.

Physiological: relating to the physical and chemical processes and functions of the human body.

Resilience: the ability of a social or ecological system (i.e. person, community, building, physical region) to absorb disturbances while retaining the same basic structure, functions and capacity to adapt to stress and change.

Respiratory disease: condition affecting the organs and tissues relating to the respiratory system (inhalation and exhalation of air).

Thermal comfort: a condition of mind that expresses satisfaction with the surrounding thermal environment; when someone feels neither too hot nor too cold.

Thermal mass: the ability of a material to absorb and store heat. High-density materials such as concrete, bricks and tiles have high thermal mass, while lightweight materials such as timber have low thermal mass. Thermal mass is used in buildings to provide steady indoor temperatures; materials with high thermal mass absorb the heat from within the building during the day, and then expel it slowly when temperatures drop (e.g. at night).

Thermoregulation: the process that enables the human body to maintain its core internal temperature (37°C). Mechanisms within the body, such as sweating and expansion of blood vessels, help return the body to a state of even internal temperature (homeostasis) if external environmental conditions create increases or decreases in the body's temperature.

Urban heat island effect: higher temperatures in dense urban areas than in the surrounding rural areas, due to the presence of man-made heat sources such as hard surfaces and waste heat generated by energy usage.

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