Overheating in care settings: magnitude, causes, preparedness and remedies

Abstract

Research in UK and elsewhere has highlighted that older people are particularly vulnerable to negative health effects of overheating. This paper examines the magnitude, causes, preparedness and remedies for addressing the risk of summertime overheating in four case study residential care and extra-care settings across the UK, spanning different building types, construction and age. The methodological approach adopted is interdisciplinary, drawing from building science and social science methods, including temperature monitoring, building surveys, and interviews with design and management teams.

The findings suggest that overheating is a current and prevalent risk in the case study schemes, yet there is currently little awareness or preparedness to implement suitable and long-term adaptation strategies (eg. external shading). There was a perception from designers to managers, that cold represents a bigger threat to older occupants' health than excessive heat. A lack of effective heat management was found across the case studies that included unwanted heat gains from the heating system, confusion in terms of responsibilities to manage indoor temperatures, and conflicts between window opening and occupant safety. Given that care settings should provide protection against risks from cold and hot weather, design, management and care practices need to become better focused towards this goal.

Key words:

Overheating; residential care homes; extra care homes; environmental monitoring

1. Introduction

Climate change is expected to result in hotter, drier summers in the UK with increased frequency, intensity and duration of high external temperatures (DEFRA, 2011). This is expected to have a significant impact on internal temperatures within buildings; causing overheating which can affect the thermal comfort of the occupants (Zero Carbon Hub (ZCH), 2015; Hames and Vardoulakis, 2012) and result in negative impacts on the health and well-being of the population (DEFRA, 2012). Furthermore many new buildings having high levels of thermal insulation and airtightness in order to minimise heat loss which can prevent the dissipation of unwanted heat, particularly in summer (ZCH, 2014; NHBC, 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 unwanted heat during summer (NHBC, 2012; DEFRA, 2012).

The risk of excessive heat for the vulnerable population (elderly, disabled, socially isolated etc.) has been recognised by the UK Climate Change Risk Assessment (CCRA, 2014). Older people are generally at greater risk of increased high temperatures, with physiological studies showing that the body's response to heat is impaired with age (Kenny et al, 2010) and chronic or severe illnesses such as heart conditions, respiratory disease or severe mental illness (PHE, 2014; Koppe et al, 2004; Gasparrini et al, 2012). Epidemiological evidence indicates that older people are particularly vulnerable to the effects of excessive heat (Åström et al, 2011). Whilst health and age can impede a person's capacity to adapt, socio-cultural and personal factors also affect a person's adaptability. Older healthy persons do not necessarily perceive themselves to be vulnerable (Abrahamson et al, 2009) and therefore do not prepare for extreme weather events effectively (Wolf et al, 2010). Older people also 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.

Studies (Kovats et al, 2006; Fouillet et al., 2006; Mackenbach and Borst, 1997; Holstein et al, 2005) indicate that heat-related mortality during heatwaves (short periods of higher than seasonally expected temperatures) was highest in relative terms amongst occupants of residential and nursing homes, despite the presence of care staff that could act to protect vulnerable residents. A German study also found an increased heat-related mortality risk amongst all nursing-home residents regardless of age (Klenk et al, 2010), while in the heatwave experienced across Europe in 2003, a study indicated that in France, mortality was highest in the least physically frail residents (Holstein et al, 2005). With the UK's ageing population projected to continue (Office of National Statistics, 2014), resulting in an increase in population aged over 75 from 8% of the total population in 2012 to 13% in 2035, overheating in buildings inhabited by generally older and more vulnerable people, such as residential care and extra care schemes, is a significant area of concern.

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 can impact (positively and negatively) on the building's risk of summertime overheating;

including 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). Recent research (Walker et al, 2015; Brown, 2010; Neven et al, 2015) also indicates that the regulatory context and business considerations of a care scheme focus on the provision of good care, which is associated with ensuring no resident is too cold and that they are secure and safe (Walker et al, 2015). These considerations reinforce the idea that care settings should be 'warm' places.

Since the European heatwave of summer 2003, there has been considerable attention paid to national preparations and responses to periods of hot weather across European countries, including in the UK, particularly in relation to vulnerable persons such as those who live in care and extra care schemes. Amongst other things this has culminated in the Heatwave Plan for England (PHE, 2015), which is linked to the UK Met Office Heat-Health Watch Service (system that provides early warning of periods of high temperatures which may affect the health of the UK public). The Heatwave Plan provides practical advice on what should be done to prepare for (long-term, all year round), and deal with hot weather (short-term actions) within health and social care settings, including providing a 'cool' room that remains below 26°C before, during and after a period of weather above the Heat-Health Watch Service (HHWS) regional threshold temperatures. Despite this, there is some 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). However, the scale of the issue for existing care settings is relatively unknown due to most heat-related health risk studies focussing on the relationship between external temperatures and heat-related excess deaths during the summer months. Yet, understanding the relation between indoor temperature and health is probably more critical (CCC, 2014) due to the range of factors mediating the relation between indoor and outdoor temperature, including building design and occupants' thermal comfort practices (Dengel and Swainson, 2012).

Within this context, this paper investigates the *magnitudes*, likely *causes*, *preparedness* and *remedies* for addressing the risk of summertime overheating in four case study care schemes (two residential and two extra care), located across the UK. This is achieved by:

- Assessing the *magnitude* (prevalence) of overheating through physical monitoring of indoor (covering residential, communal and office spaces) and outdoor temperatures over one summer period across the four case studies.
- Evaluating the potential *causes* of overheating and *preparedness* for tackling overheating through building surveys and interviews with key members of the design and management teams.
- Identifying *remedies* in terms of appropriate recommendations for practitioners (designers, care providers, housing providers), regulators (Care Quality Commission), policy-makers (Department of Communities and Local Government (DCLG) and Department for Environment, Food and Rural Affairs (DEFRA)) and care staff.

2. Research study and approach

A case study based approach was adopted in this research study, focussing on two residential care homes and two extra-care facilities to demonstrate the risk of overheating in environments with different levels of care provision. While a *care home* is generally for older people with frailties (physical and cognitive), providing them with single private bedrooms but with access to communal social spaces and on-site care services with meals provided and staff on call 24 hours a day, an *extra-care scheme* is designed to accommodate older people who are becoming frailer and less able, but who still require and/or desire some level of independence. Extra-care housing schemes provide varying levels of care and support; at a minimum, there will be some kind of on-call assistance for people in an emergency, but not necessarily physical presence 24 hours-a-day, as is available in residential care homes. Extra-care schemes also usually provide self-contained units, consisting of a kitchen, living/dining area, bathroom and one or two bedrooms, in addition to communal social facilities. Such differences in care provision and physical facilities mean that residential care homes are operated in a different manner to extra care facilities; the more independent residents in extra care schemes are generally afforded greater responsibility and control over their thermal environment than residents in residential care schemes, where it is expected that due to their frailties, the staff are more likely to exert control. Also as confirmed by Flyvbjerg (2006) a detailed examination of a single or few case examples can provide reliable information about the broader class.

The four case studies are located in North England (one care home), South West England (one extra-care), and two in the South East England (one care home and one extra-care) (Figure 1). They were selected based on ownership (public and private care), variation in built age (and related building regulation context) and location. All but one are managed by not-for-profit organisations. The average age of the residents ranged from 85-89 years old.

<<<INSERT FIGURE 1 HERE>>>

Figure 1. Locations of four case study buildings.

Table 1 outlines the key characteristics of the case studies and other important criteria (ventilation, construction type) considered during the selection process. It must be noted that due to issues with recruitment (schemes simply being unable to provide adequate time and access), the case studies were relatively self-selecting which may mean that they have some degree of pre-existing interest in overheating and climate change.

Table 1.Summary of characteristics of the four case study care settings.

<<<INSERT TABLE 1 HERE>>>

The research approach was interdisciplinary, drawing from building science and social science methods, and involved conducting primary research across the four case study schemes as follows:

- Monitoring of indoor and outdoor temperatures at 15-minute intervals over the summer months from June to September 2015. Thirty-three rooms across the four case studies were monitored, which included communal areas, offices and resident rooms/flats.
- Building surveys of the case studies were undertaken to identify building design features that may enable or prevent occupants (staff, residents) to control their thermal environment during periods of hot weather.
- Semi-structured interviews were conducted during September 2015 with five designers and four asset managers involved in the four case study buildings. The interviews focussed on understanding the impact of briefing, building design and management of the schemes on overheating.

3. Overheating metrics and care settings

Overheating, whilst a widely used term, is currently neither precisely defined nor understood and can be assessed in relation to thermal comfort, health or productivity (Zero Carbon Hub, 2015). 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. Hence there is inconsistency regarding what particular conditions may constitute overheating (Dengel and Swainson, 2012), although the Zero Carbon Hub (2015) has recently attempted to address this issue for housing.

This lack of definition of overheating means that there is a multitude of overheating assessment metrics (Table 2), generally based on either temperature-health effects or thermal comfort indicators.

Within the health, and more specifically, the care sector there is guidance on (outdoor) threshold temperatures at which heat-related deaths are expected to increase, such as 24.5°C (Public Health England (PHE) Heatwave Plan guidance, 2014). However, apart from PHE Heatwave Plan guidance indicating that at least one room in care schemes should be kept below 26°C in order to provide a 'cool area', there is a lack of guidance or standards in terms of indoor temperatures at which overheating occurs in care settings, and the level of associated risk to health.

In the 'building' sector, there are several overheating metrics with different internal temperature thresholds which focus mainly on thermal comfort comprising both 'static' and 'adaptive' approaches. Whilst CIBSE has adopted the adaptive approach in recent years, there is much discussion (ZCH, 2015; ZCH, 2016) as to whether or not this is wholly appropriate, particularly in buildings where the occupants are less able to adapt to their local environment, such as care homes and accommodation for vulnerable occupants.

The static approach enables simple calculations to be undertaken when assessing the performance of building. The main criteria for identifying the overheating risk according to the static approach are:

- Overheating in (non air-conditioned) bedrooms occurs when the indoor operative temperature is over 26°C for at least 1% of occupied hours.
- Overheating in (non air-conditioned) living rooms and offices occurs when the indoor operative temperature is over 28°C for at least 1% of occupied hours.

In contrast, the adaptive approach as described in CIBSE (2015) accounts for the adaptation of occupants to their environmental context within free-running buildings. It is based on the presumption that the occupants have adapted to external temperatures during the preceding few days, i.e. the running mean (T_{rm}) to create an allowable indoor operative temperature in relation to the external temperature:

$$T_{com} = 0.33T_{rm} + 18.8$$

In terms of specific overheating criteria, three overheating criteria are provided in CIBSE TM52 (2013), of which, if two are failed, overheating is deemed to have occurred (Table 3).

Table 3. Overheating criteria for the adaptive overheating approach as outlined in CIBSE Guide A (2015) and CIBSE TM52 (2013).

<<<INSERT TABLE 3 HERE>>>

The adaptive approach also takes into consideration the sensitivities of occupants, and differing levels of thermal expectations, such as Category I (High level of expectation only used for spaces occupied by very sensitive and fragile persons), where the suggested acceptable comfort range is ±2K from the temperature calculated from the running mean of the outdoor temperature, T_{rm}:

$$T_{max} = 0.33T_{rm} + 20.8$$

In terms of this study, Category I is used for residential and communal areas and Category III (acceptable, moderate level of expectation and used for existing buildings) is used for the office areas.

In terms of assessment of overheating and thermal comfort within the care sector specifically, there have been relatively few studies, particularly in temperate climates similar to that of the UK's in order to ascertain what constitutes 'thermal comfort' within the care sector specifically (CCC, 2014). While one study showed that elderly people require higher temperatures in order to achieve thermal comfort (Mendes et al, 2013), further studies indicate that this may be in part due to a prevalent perception that older people require warmer conditions, rather than an accurate representation of this demographic (Walker et al., 2015). This is why it is important that health related thresholds are used when evaluating care settings for overheating, due to the specific vulnerabilities of this demographic group, as highlighted through both physiological and epidemiological studies (PHE, 2014; Åström et al, 2011; Koppe et al, 2004; Gasparrini et al, 2012), and the potential inability to gather information on thermal comfort from physically and cognitively frail residents. To further complicate matters, care sector buildings are general hybrids in nature (being both residential and work places), which means that the thermal comfort needs of the occupant’s will vary hugely, and as such, make it difficult to determine the most appropriate overheating metrics to use.

Although the static approach has its issues, in that whilst it establishes the occurrence of overheating, it does not necessarily indicate the severity of the overheating (Nicol et al, 2009), the adaptive approach was developed from research in non-domestic settings and there are doubts as to its appropriateness within a care setting, where the capacities of the residents are somewhat unique; the more vulnerable the occupants, the less likely they are able to adapt to changes in temperature. In addition, CIBSE Guide A (2015), whilst adopting the adaptive approach to assessing overheating risk, still states that a static threshold temperature is still appropriate for bedrooms; “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 recent review by the Zero Carbon Hub (2016) which sought to provide a starting point for developing a national policy or standard on overheating indicates that for bedrooms specifically, a static threshold temperature should be used, rather than an adaptive approach as, generally, a person’s ability to adapt and cool down when sleeping is more limited and the available evidence, although limited, indicates that not only is sleep affected when operative temperatures are above 25°C, but that heat-related deaths and illnesses are more likely above this temperature also.

Given this context, the main metrics used to assess overheating risk within this study include the static CIBSE Guide A (2006) overheating and thermal comfort criteria (referred to as the static approach) for all rooms; the adaptive overheating and thermal comfort approach outlined in CIBSE TM52 (2013) and CIBSE Guide A (2015), and which is based on BS EN 15251:2007 for all rooms except bedrooms; and the PHE's recommended maximum internal temperature threshold of 26°C to be maintained before, during and after a heatwave period.

It must also be noted that whilst the authors acknowledge the requirement for the operative temperature (T_{op}) to be calculated in order to undertake the above overheating risk methodologies, due to practical constraints, air temperature (dry bulb) was used as a proxy for T_{op}. According to Mavrogianni et al., (2015) this is a common limitation of monitoring studies due to cost constraints. The operative temperature and dry bulb temperatures mainly differ in indoor spaces with higher levels of exposed thermal mass or high indoor air velocity (Mavrogianni et al., 2015); neither of which were prevalent in the case study buildings within this study.

4. Monitoring of thermal conditions

External and internal data loggers were installed in the four case study schemes. The locations of the data loggers in each case study are identified on the floor plans (Appendix A). In addition, the on-site managers were informed of their locations and asked to ensure staff knew of their locations. The loggers recorded dry bulb air temperature and/or relative humidity at 15-min intervals for three months during the summer (mid June 2015 – end September 2015). Unfortunately, due to participant availability and practical restrictions, it was not possible to install all loggers across the four case studies on the same date so the temporal coverage varies slightly for each case study.

The external data loggers used were Onset HOBO U23 Pro v2 and measured external temperature (accuracy: ±0.21°C; range: 0-50°C) and relative humidity (accuracy: ±2.5%; range: 10-90%RH). They were placed in convenient and secure locations, generally just above ground level (0.5-1.0 metres above) and away from sources of direct and reflective heat and light sources. The internal data loggers used were Onset HOBO U12 (temperature (accuracy: ±0.35°C; range: 0-50°C) and relative humidity (accuracy: ±2.5%; range: 10-90% RH)) and Maxim Integrated ibutton DS1922L (temperature only; accuracy: ±0.5°C; range: -10-65°C). In total, 34 internal data loggers were installed. They were placed in convenient and secure locations to prevent removal by either staff and/or residents. The internal data loggers were placed at around 1.80 m from floor level and away from sources of direct light and heat such as light bulbs, radiators or large electronic appliances). However, two were lost (one in the communal area in Case Study A; one in a bedroom in Case Study B), apparently due to their removal by either staff or residents. The loss of the data loggers highlights the difficulties of monitoring spaces with remote researchers and active on-site occupants. No data was retrieved from these loggers. Despite this, across the four case studies, data was available for 17 residential rooms including six living rooms (extra care units only; Case Studies C and D) and 11 bedrooms, eight communal areas (lounges and dining areas) and eight offices.

During their installation, information relating to the different occupancies of the rooms was gathered (Table 4). Information on construction materials (including building types, insulation levels and glazing types) and heating/cooling/ventilation systems and controls installed were also gathered during a building survey and through a desktop review of technical specifications and architectural drawings.

Table 4 Occupancy profiles for the monitored rooms for which data are available.

<<<INSERT TABLE 4 HERE>>>

5. Magnitude of overheating risk

Overall, the summer of 2015 was cool and wet; with the Met Office (2016) reporting that despite the mean annual temperature being 0.4°C above the 1981-2010 long-term average, the monthly mean temperatures from May to September were below average (e.g. July mean temperature was 14.4°C; 0.7°C below 1981-2010 average). However, a new UK temperature record of 36.7°C (Heathrow, London) was set on 1st July and external temperatures across all regions of the UK were particularly high over this short period of time. Although the Met Office refers to this as a one-day heatwave, it is worth noting that there is no official UK definition of a heatwave except for the following; "a heatwave is an extended period of hot weather relative to the expected conditions of the area at that time of year." (Met Office, 2016). Generally, the Met Office uses the World Meteorological Organisation (WMO) definition of a heatwave which is "when the daily maximum temperature of more than five consecutive days exceeds the average maximum temperature by 5°C, the normal period being 1961-1990."

There were no heatwave periods, as defined by the WMO during the monitoring period. However there were periods in which localised external temperatures in Case Studies A and D met the trigger temperature thresholds of the PHE's Heat-Health Watch Service (HHWS), upon which the PHE's Heatwave Plan is based, and which are referred to as heatwaves in PHE guidance and documentation.

Table 5 presents the average mean and maximum temperatures over the monitoring period across different spaces, and results from the overheating analysis. Relatively, the residential areas (private bedrooms and living rooms) were the most susceptible to overheating. About 16 out of the 17 residential rooms (across all case studies) overheated according to the static approach, including all bedrooms. In terms of the adaptive approach, two living rooms in Case Study C overheat.

Five out of the eight communal areas overheated during the monitoring period according to the static approach, whilst only three (all in Case Study D) overheated according to the adaptive approach. Four out of the eight offices monitored overheated according to the static approach, whilst only one (Manager's office, Case Study B) overheated according to the adaptive approach. Due to the small sample size, it is difficult to ascertain the impacts of orientation, size and location of individual rooms on the overheating risk; particularly as the differences in temperatures could be due to individual occupant behaviour, which was not recorded in detail during the study. However, the fact that the temperatures in similar rooms (such as Case Study D flats with the same orientation, window opening and floor area) varied, suggests that overheating is as much to do with heat management within the individual rooms, as the overall design.

Across the monitored spaces, the average mean indoor temperatures were relatively high. CIBSE guidance (2015) on thermal comfort indicates that in bedrooms, thermal comfort and quality of sleep decreases in temperatures above 24°C. Overall, nine out of the 11 bedrooms monitored had an average mean temperature of 24°C or above, and the average mean temperature across all the bedrooms was 24.5°C. In the other room types (private living rooms, communal areas and offices), the average mean temperatures across the monitored rooms were 25.5°C, 24.7°C and 25.7°C respectively. This is also significant as PHE guidance (2015) indicates that at 24.5°C excess heat-related deaths become apparent; suggesting that the temperatures within all the case study buildings could be resulting in both thermal discomfort and increased health risks. In addition, as Table 5 indicates, *all* rooms have maximum temperatures above 26°C (the PHE indoor threshold temperature for 'cool rooms'). Indoor temperatures appear highest in Case Study D, where five of the 10 rooms monitored have average mean temperatures above PHE indoor threshold temperature.

Table 5. Overheating results from monitoring of key rooms with case study buildings over summer period (June – September 2015).

<<<INSERT TABLE 5 HERE>>>

Figure 2 indicates when the risks are occurring and when static threshold temperatures (CIBSE Guide A, 2006; PHE, 2015) are being reached across the different room types in Case Study D. Temperatures in the bedrooms do not fall to recommended summer comfort temperatures until September, when external temperatures (day and night) have also reduced. Furthermore, for a significant period of time, the internal temperatures of the flat living rooms and communal areas are around or above the PHE's recommended temperature threshold for 'cool rooms'. This is particularly noteworthy as the 'cool room' threshold is reached even when the external temperatures have not breached the Heat-Health Watch thresholds (day max=31°C; night min=16°C) that indicate action is required. In addition, Figure 2 demonstrates that both the offices, despite Office 2 being air-conditioned are above CIBSE (2006) recommended static comfort levels for the majority of the monitored period. Figure 2 also highlights that, except for the office areas, there are distinctive 'spikes' in the internal temperatures that correspond with the period of high external temperatures around 1st July.

<<<INSERT FIGURE 2 HERE>>>

Figure 2 Indoor temperatures in monitored rooms in Case Study D (June-Sept 2015). ***Note: horizontal grey band in Offices graph indicates summer comfort temperature range for air-conditioned offices (Office 2 is air-conditioned).***

Figure 3 demonstrates the correlation in Case Study A between external and internal temperatures during a period in which the HHWS trigger temperature thresholds (day max=29°C; night min=15°C) were achieved; 29th June to 2nd July 2015. During this period, indoor temperatures within all rooms rose by approximately 2 degrees during the first day alone. Furthermore, on the second day, both the indoor and external temperatures rose again, resulting in all of the monitored rooms experiencing temperatures above the PHE Heatwave Plan recommended threshold temperature for 'cool rooms' of 26°C. Whilst this is likely to have health-risk implications for the most vulnerable residents, it must also be noted that in the period leading up to the short-term high external temperatures, temperatures in all rooms were already above static indoor summer comfort temperatures during occupied hours (23°C in bedrooms; 25°C in offices and living areas. CIBSE, 2006); indicating a high likelihood of thermal discomfort for all occupants (staff and residents) during this period. The communal lounge was the only room in which overnight temperatures dropped to similar levels as those prior to the hot weather period. The temperatures in the residential and office areas remained relatively high and only resumed previous levels after one day and two nights. This suggests that the existing design measures (such as the thermal mass of the building retaining heat) and heat management strategies in these areas (such as ventilation) were not enough to bring down indoor temperatures during short periods of high external temperatures.

<<<INSERT FIGURE 3 HERE>>>

Figure 3. External and indoor temperatures in Case Study A during period of local external temperatures reaching PHE Heat-Health Watch Service thresholds. ***Note: Dotted horizontal line outlines threshold temperature for PHE recommended 'cool areas' during heatwave period.***

Although thermal comfort surveys were not undertaken (as majority of residents were physically and cognitively frail), informal discussions with both staff and residents during the building survey indicated that three case studies (Case Studies A, C and D) were generally considered to be very warm during summer; particularly Case Studies C and D. This is worth noting as these two case studies are the extra care facilities, and control over ventilation and cooling is split between staff and residents, in comparison to the two residential care homes in which thermal control appeared to, generally, be the responsibility of the staff only. A number of staff also commented on the disparity between their perception of thermal comfort with that of the residents who were much more sedentary. Since 'keeping warm' was perceived to be related to good care, staff expected to experience higher levels of thermal discomfort, particularly in terms of being too hot, in order to ensure the thermal comfort of residents. Although staff tolerated high indoor temperatures to be part of their job, it raises concerns about their risks to their health. Interestingly some staff members noted that they actually felt cooler in the summer than the winter, in part because they were more able to encourage the opening of windows and use of electric mobile fans.

6. Potential causes of overheating in care settings

It is well-recognised that building design plays a significant role in terms of exacerbating or mitigating high temperatures particularly in terms of its ability to minimise heat gain (solar and internal), maximise excess heat loss during hot weather periods (summer) and enable effective heat management by occupants (Gething and Puckett, 2013; Gale et al, 2011; McHugh and Keefe, 2012; Tregenza and Wilson, 2011). All four case studies had some design features that could either exacerbate or reduce the risk of overheating (summarised in Table 6). The key design features that were designed to tackle overheating included brise soleil (Case Study C, Figure 4), overhanging eaves (Case Study C) and large balconies (with further in-built space for planting and green vegetation) to provide additional shading on south-facing facades (Case Study D, Figure 5).

<<<INSERT FIGURE 4 HERE>>>

Figure 4. External shading design features in Case Study C include fixed brise soleil and overhanging eaves.

<<<INSERT FIGURE 5 HERE>>>

Figure 5. External shading design features in Case Study D include deep balconies.

Table 6. Assessment of design features of the case study buildings in relation to their potential impact on overheating risk.

<<<INSERT TABLE 6 HERE>>>

Building surveys (combination of walk-through and inspection of buildings from outside and inside) helped to uncover likely reasons for the occurrence of overheating which were not apparent otherwise. For example, conflicts were discovered between design strategies (for passive cooling) and other priorities such as resident requirements, safety and security that hindered effective management of heat. Across all the case studies, residential areas were found to be mostly single aspect spaces lacking through ventilation due to practical, spatial and care requirements. Internal shading (blinds, curtains) were common but keeping blinds closed during the day as a remedial measure was found to be feasible only where rooms were unoccupied, as residents needed to see out and have access to daylight (Figure 6). Window restrictors were installed to maintain safety and security of residents, although it limited occupants' ability to open windows to provide adequate ventilation (Figure 7). The design of heating and ventilation controls also appeared to impact upon the occupants' ability to manage their thermal environment effectively. In Case Study D lever handles, were considered to be not appropriate for a care setting due to the physical frailties of some residents. As a result staff had adapted the lever handles in one flat using bike handlebars to make them longer for a resident with severe arthritis to still be able to open and close their windows.

<<<INSERT FIGURE 6 HERE>>>

Figure 6. Curtains in residents' room closed to reduce solar gain during the day.

<<<INSERT FIGURE 7 HERE>>>

Figure 7. Window restrictors placed on most windows, including ground floor (Case Study D).

Although all three recently-built case studies (A, C and D) had trickle vents installed in windows to ensure continuous background ventilation, they only appeared to be in regular use in Case Study D. In the flats in Case Study C, even on a hot day, the trickle vents remained closed (Figure 8). This appeared to be due in part to the occupants' being unaware they were there, and also an expectation that they had already been opened by the staff. In Case Study A trickle vents had been painted over (most likely by maintenance staff) (Figure 9), highlighting the need for communicating to building management and maintenance staff, the purpose of such strategies.

<<<INSERT FIGURE 8 HERE>>>

Figure 8. Trickle-vents in windows closed during summer months in private residential flat in Case Study C.

<<<INSERT FIGURE 9 HERE>>>

Figure 9. Trickle-vents in windows painted closed in Case Study A.

The building surveys also uncovered a lack of effective heat management practices. Across all four case studies, it was found that the centralised heating and hot water system remained on, and in use, throughout the year, resulting in unwanted summer heat gains. In part this was due to the need for hot water in individual bedrooms (care units) and flats (extra care units) as well as the varied heating requirements of individual residents; some were reported to want additional heating even during the summer months, whereas others did not. Due to this variety in requirements, there was evidence of heating controls being adapted to remove access from residents, particularly in the resident rooms of care settings (Figure 10) and communal areas (care and extra care settings) to ensure more effective management of heating. Despite this, even in areas under staff 'control' (such as communal areas), thermostats settings were set very high (Figure 11). Furthermore in case study D, installation issues with the heating system itself (the exact cause was unknown) meant that residents had been asked by the management to keep the thermostat in their bathrooms on ‘max’ (over 30^{o}C), which they subsequently were doing.

<<<INSERT FIGURE 10 HERE>>>

Figure 10. Radiators covered to prevent access by residents in Case Study B.

<<<INSERT FIGURE 11 HERE>>>

Figure 11. Thermostat in corridor set to 27°C in summer in Case Study C.

Semi-structured interviews with designers and asset managers highlighted the impact of common procurement methods such as *Design & Build* that involves a single main contractor undertaking all aspects of the work (who may appoint several disparate subcontractors), while the initial designer of a care scheme may not be 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, roof design and specification was changed from concrete (high thermal mass which 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, led to inadequate user understanding for operating heating and ventilation systems. Moreover it was often the building management team that undertook the handover process, rather than the on-site end-users themselves (care staff).

In addition, lack of adequate internal communication was also discovered within the care organisations, which was in part due to the separation of building management teams (usually based off-site) from care staff, with the result that responsibility for heating control was removed from the daily users (care staff and residents), and they were not always able to alter temperatures. Several of the asset managers also commented on the practical difficulties in achieving full communication with on-site staff, acknowledging that there was a relatively high turnover of care staff. This led to lack of agency as well as confusion surrounding responsibilities within on-site staff, subsequently resulting in contradictory actions (windows left open with heating on) or even inaction by staff.

7. Preparedness for tackling overheating

To assess the *preparedness* for tackling overheating in care settings, semi-structured interviews were conducted with the designers and asset managers (involved in the case studies) who highlighted a number of factors relating to the design, briefing and management of care scheme developments that are likely to impede preparedness. An underlying culture of ‘warmth’ was prevalent, with the predominant attitude within both the designers and managers that being ‘too cold’ was the issue, rather than ‘too warm’.

> *“We focus on keeping people warm in the winter that’s our main focus.”* (Manager)

Such views have a strong factual basis; cold is strongly associated with mortality. Recent estimates indicate there are currently 41,000 premature deaths caused by cold weather in the UK annually compared to just 2,000 premature heat-related annual deaths (CCC, 2014). Furthermore, future projections indicate that cold-related deaths in the UK are expected to remain high (Hajat et al, 2014). However, most studies (e.g. Vardoulakis and Heaviside, 2012; CCC, 2014) also indicate that excess heat-related deaths in the UK are expected to increase significantly; with one study (Hajat et al, 2014) suggesting an increase to approximately 7,000 a year by the 2050s.

There was also a lack of awareness of the heat related risks of climate change, and subsequent low prioritisation of design measures for avoiding overheating. One designer stated that when designing and developing the briefing for care schemes, overheating was seen as *“the poor sister…to other aspects of climate change.”* This appeared to be, in part, due to the ‘warmth culture’ as well as a relatively unconcerned attitude, particularly amongst some managers, towards heatwaves, which were seen as something that only occurs rarely in the UK, and as such could be managed through short-term adaptation practices, such as mobile electric fans. Both the designers and asset managers also indicated that there was a lack of understanding of long-term measures to mitigate overheating;

“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 [building] industry as a whole.” (Designer).

The lack of standardised advice, calculations and standards in relation to the assessment of the overheating risk during the design stage was also felt to exacerbate the lack of awareness, particularly, as one designer pointed out that modelling of thermal environment for Building Regulations focused on energy and carbon savings, rather than overheating specifically. Furthermore all but one asset manager (Case Study A) stated that overheating was not considered a risk within the lifetime of the schemes they were developing and commissioning, and as such was not part of long-term strategic planning;

"I don't know… the impact of what's going to be over what sort of timescale for a business like this… I struggle I guess to anticipate that in the lifetime of this business that it's going to become a huge issue."

The interviewees also noted that where there were conflicts due to other priorities, more often than not, the other priorities took precedent. An example of this was the need for care organisations with several developments to run their individual schemes efficiently. Two of the asset managers highlighted this had led to an increase in the use of building management systems (BMS) and centralised heating and hot water systems that could be managed off-site, which took away responsibility for heating control from the daily users (care staff and residents), and they were not always able to alter temperatures.

During periods of hot weather, most of the reported measures undertaken were relatively short-term and reactive, such as providing mobile electric fans or localised air conditioning units as well as care practices as outlined in the PHE's Heatwave Plan (2015) such as;

"…keeping them [windows] closed, keeping your blinds down, getting your fans, pushing your fluids, all that sort of stuff, putting people in light clothing and all the things that you would typically do to keep the building nice and shady and as cool as we can…" (Asset Manager)

The managers indicated that they felt this was sufficient in terms of tackling current overheating risk, particularly as they had not had significant overheating problems reported to them by on-site staff. In addition, the management of overheating was generally left to the carers (frontline care staff) and there were no organisation-wide strategic management plans, except for the PHE's Heatwave Plan for England (2015), which the managers expected carers to implement. As such, the approaches to heat management taken by the case studies appeared to be reactive rather than proactive, and indicate a lack of preparedness for addressing overheating risks.

8. Discussion and recommendations

The environmental monitoring and overheating analysis has revealed the occurrence of overheating in summer 2015 across all four schemes, which raises concerns regarding the future risk of overheating in a warming climate. The study also highlighted the lack of monitoring and awareness of localised external and internal temperatures as part of building management. This emphasises the need to regularly monitor indoor (and outdoor) temperatures in care settings, with feed-back to management, frontline care staff and residents to identify any occurrence of overheating and support timely action.

The differences between the results of the static and adaptive approach analyses suggest that the adaptive approach could be underestimating the overheating risk, particularly in relation to buildings and rooms occupied mainly by vulnerable persons (or those less able to adapt). Whilst there is some overlap between static threshold temperatures in building sector guidance (as in CIBSE Guide A) and health-related guidance (as set out in PHE's Heatwave Plan), fundamentally there is a lack of evidence on appropriate temperature thresholds (for health and thermal comfort) within the care sector and, specifically for older people. Combined, this is likely to lead to confusion and lack of prioritising of the risk and understanding of how to identify when and where overheating may occur. This issue was reflected in the prioritisation of other design, spatial, cost and care requirements and needs over overheating, and a lack of long-term strategic planning and preparedness for overheating mitigation.

Throughout the study, there was a prevalent perception, from care scheme designers to managers, that older people 'feel the cold,' and that cold represents a bigger threat than heat to older occupants' health. While cold is still more prevalent as a health risk, there is less recognition that heat can also present a significant health risk. Heatwaves were seen as something that only occur rarely in the UK, and as such can be managed through short-term adaptation practices, such as mobile electric fans. This is why design for overheating was not found to be commonplace and innovative design solutions for overheating were not widespread within the design of care schemes. Even 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. The majority of the asset managers interviewed did 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 key finding in terms of the causes of overheating related to the management of heat in care facilities. The heating was left on throughout the summer in all of the case studies due to differing requirements of occupants and different levels of control, and capacity and separation of roles (between building management and care) particularly within the medium-sized care organisations (Case Studies A, C and D) creating confusion in terms of responsibilities to manage heating controls and indoor temperatures. These findings suggest that neither design nor management will be sufficient responses on their own. Design measures cannot necessarily be wholly protective of vulnerable residents during periods of hot weather, whilst improved management cannot fully compensate for inappropriately designed buildings that overheat significantly already, or outside extreme hot weather periods. Given that vulnerable residents are within settings that should be providing care and therefore protection against thermal risks (arising from both cold and hot weather) building design, management and care practices need to become better focused towards this goal.

Against this backdrop of research findings, key recommendations for policy-makers, regulatory/guidance bodies, care/housing providers, designers and care staff, are proposed, as shown in Table 7. Most importantly, given that there is no *statutory* maximum internal temperature for care settings, collaboration across key care and building sector bodies, such as PHE, the Care Quality Commission (CQC), Chartered Institution of Building Services Engineers (CIBSE), the Department for Environment, Food and Rural Affairs (DEFRA), the Department of Communities and Local Government (DCLG) and the Department of Health (DoH) is critical for the standardisation of health-related and thermal comfort related temperature thresholds for overheating in care settings. This will enable effective adaptation solutions specific to the care sector, to be developed and implemented.

Table 7. Recommendations for stakeholders within the care sector to enhance preparedness against overheating risks.

<<<INSERT TABLE 7 HERE>>>

8.1 Study limitations and suggestions for future research

Whilst the overheating analysis was based on individual occupancy profiles for each monitored room, a limitation of the study was the lack of thermal comfort surveys with residents, although some insight on actual thermal comfort experiences was gained through: discussions with staff and residents during building surveys, and interviews with management. Undertaking thermal comfort surveys in care settings is challenging due to the frail nature of residents, majority of which suffer from mild physical and cognitive disabilities. This would make any survey undertaken of the residents unreliable. In addition, the majority of the management were also wary of asking care staff to participate in such surveys due to time pressures; in part because the majority of the care staff were not employed by their organisation directly. Despite this practical limitation, it is recommended that further studies seek to undertake thermal comfort surveys to provide a more complete picture of the impact of overheating on the various types of occupants within care facilities. Furthermore, the study results need to be used with caution due to the small sample size and large differences between both the building characteristics and individual occupants.

Despite this, the study offers valuable insights into current summertime temperatures of the case study care facilities during a relatively 'cool' summer period, and raises a number of questions relating to the preparedness of the care sector against hot weather that could be addressed by a larger-scale monitoring and thermal comfort study of care facilities.

9. Conclusions

Whilst the study findings are more illustrative than conclusive due to the small sample size, they do add important new evidence on the current overheating risk in care and extra care settings, given that there is currently little research on the prevalence of summertime overheating in care settings in the UK. It is also found that the deployment of adaptive comfort for assessing the risk of overheating is likely to be inappropriate in spaces where residents are less able to adapt to their local environment (such as bedrooms in care homes), as it might create a false sense of reduced risk of heat stress to inhabitants. This in turn might reduce either or both the policy side's and/or the design and management side's focus on overheating as a problem that needs to be addressed - or at least diminish the true extent of the problem. The criteria for assessing overheating risk in spaces inhabited by residents having limited opportunity for adaptation, forms an important area for research, if adequate facilities are to be provided for the ageing and vulnerable population in the UK.

The findings also suggest that overheating is a current risk in the care sector that is likely to be exacerbated in the future due to climate change, yet there is currently little awareness and implementation of suitable and long-term adaptation approaches (such as external shading, provision of cross-ventilation). Such strategies require input from designers, development teams, care providers, care managers and frontline staff. Yet such fundamental change also requires support, in terms of 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 risks posed by elevated temperatures are prioritised alongside risks from cold.

(Number of words excluding abstract and references: 7765)

10. References

Abrahamson, V., Wolf, J., Lorenzoni, I., Fenn, B., Kovats, S., Wilkinson, P., & Raine, R. (2009). Perceptions of heatwave risks to health: interview-based study of older people in London and Norwich, UK. *Journal of public health*. 31(1): 119-126.

Adams, S. and White, K. (2006). *Older People, Decent Homes and Fuel Poverty: an analysis based on the English House Condition Survey.* London: Help the Aged.

AEA. (2011). *Vulnerability to heatwaves and drought: adaptation to climate change.* York: JRF.

Åström, D. O., Fosberg, B. & Rocklöv, J. (2011). Heatwave impact on morbidity and mortality in the elderly population: A review of recent studies. *Maturitas.* 69: 99-105.

Barnes, S., Torrington, J., Darton, R., Holder, J., Lewis, A., McKee, K., Netten, A. and Orrell, A. (2012). Does the design of extra-care housing meet the needs of the residents? A qualitative study. *Ageing and Society*. 32: 1193-1214.

British Standards Institution. (2012). *BS EN 15251:2007 Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics.* British Standards Online.

Brown, S. (2010). *In the Heat of Power: Understanding Vulnerability to Heatwaves in Care Homes for Older People.* PhD Thesis, Lancaster University.

Burns, A. (2008). *POE of Colliers Gardens in Bristol. Report for Post-occupancy evaluation course,* Oxford Brookes University.

Chartered Institution of Building Services Engineers (CIBSE). (2006). *Environmental design, CIBSE guide A.* London: CIBSE.

Chartered Institution of Building Services Engineers (CIBSE). (2013). The limits of thermal comfort: avoiding overheating in European Buildings. Technical Memorandum 52. London: The Chartered Institution of Building Services Engineers (CIBSE).

Chartered Institution of Building Services Engineers (CIBSE). (2015). *Environmental design, CIBSE guide A.* London: CIBSE.

Chartered Institution of Building Services Engineers (CIBSE). (2016). CIBSE Weather Data Sets. Available online at: http://www.cibse.org/weatherdata

Committee on Climate Change (CCC) Adaptation Sub-Committee (ASC).(2014). *Managing climate risks to well-being and the economy.* Available at: http://www.theccc.org.uk/wp-content/uploads/2014/07/Final_ASC-2014_web-version-4.pdf

Dengel, A. and Swainson, M. (2012). *Overheating in New Homes – A Review of the Evidence.* Milton Keynes: NHBC Foundation.

Department for Environment, Food and Rural Affairs (DEFRA). (2011). *UK climate change projections. Department for Environment, Food and Rural Affairs.* London: HMSO.

Department for Environment, Food and Rural Affairs (DEFRA). (2012). *UK Climate Change Risk Assessment: Government Report*. London: HMSO.

Eames, M., Kershaw, T., & Coley, D. (2011). On the creation of future probabilistic design weather years from UKCP09. *Building Services Engineering Research and Technology.* 32(2): 127-142.

EEA (European Environment Agency) (2012). Observed global fossil fuel CO2 emissions compared with six scenarios from the IPCC, http://www.eea.europa.eu/data-and-maps/figures/observed-global-fossil-fuel-co2

Fouillet, A., Rey, G., Laurent, F., Pavillon, G., Bellec, S., Guihenneuc- Jouyaux, C., Clavel, J., Jougla, E. & Hemon, D. (2006). Excess mortality related to the August 2003 heatwave in France. *International Archives of Occupational and Environmental Health.* 80: 16–24.

Flyvbjerg, B (2006) Five misunderstandings about case-study research, *Qualitative Inquiry* 12 (2): 219-245.

Gale, D., Fitzsimmon, J., Gartner, T. & Gale, M. (2011). *St. Loyes ExtraCare4Exeter: A report for the Technology Strategy Board.* London: TSB.

Gasparrini, A., Armstrong, B., Kovats, S. and Wilkinson, P. (2012). The effect of high temperatures on cause-specific mortality in England and Wales. *Occupational and Environmental Medicine*. 69 (1): 56-61.

Gething, B. and Puckett, K. (2013). *Design for Climate Change.* London: RIBA Publishing.

Guerra Santin, O., & Tweed, A. C. (2013). *Summer post occupancy evaluation of a Passivhaus care home in the UK*. In *Conference:* PLEA Sustainable Architecture for a Renewable Future.

Gupta R and Gregg M. (2013). Preventing the overheating of English suburban homes in a warming climate. *Building Research & Information.* 41(3): 281–300.

Gupta R, Gregg M and Williams, K. (2015). Cooling the UK housing stock post-2050s. *Building Services Engineering Research and Technology.* 36(2): 196-220.

Hajat, S., Vardoulakis, S., Heaviside, C. and Eggen, B. (2014) 'Climate change effects on human health: projections of temperature-related mortality for the UK during the 2020s, 2050s and 2080s', *Journal of Epidemiology and Community Health*, Vol. 68, pp. 641–8

Hames, D. and Vardoulakis, S. (2012). *Climate Change Risk Assessment for the Health Sector.* London: DEFRA.

Harlan SL, Declet-Barreto JH, Stefanov WL, Petitti DB. (2013). Neighborhood Effects on Heat Deaths: Social and Environmental Predictors of Vulnerability in Maricopa County, Arizona. Environmental Health Perspectives 121:197–204; http://dx.doi.org/10.1289/ehp.1104625

Holstein, J., Canouï-Poitrine, F., Neumann, A., Lepage, E., & Spira, A. (2005). Were less disabled patients the most affected by 2003 heat wave in nursing homes in Paris, France? *Journal of public health.* 27(4): 359-365.

Innovate UK. (2015). Design for Future Climate. https://connect.innovateuk.org/web/design-for-future-climate/projects-outputs

Kenny, G. P., Yardley, J., Brown, C., Sigal, R. J., & Jay, O. (2010). Heat stress in older individuals and patients with common chronic diseases. *CMAJ : Canadian Medical Association Journal*, *182*(10), 1053–1060. http://doi.org/10.1503/cmaj.081050

Klenk, J., Becker, C. & Rapp, K. (2010). Heat-related mortality in residents of nursing homes. *Age and Ageing.* 39: 245-252.

Koppe, C., Kovats, S., Jendritzky, G. & Menne, B. (2004). *Health and Global Environmental Change – Series 2, No.2 – Heat-waves: Risks and Responses.* Denmark: World Health Organisation.

Kovats, R. S., Johnson, H., & Griffith, C. (2006). Mortality in southern England during the 2003 heat wave by place of death. *Health Stat Q.* 29(3).

Lewis, A. 2014. *Energy Use in an Ageing Society: The Challenges of Designing Energy-Efficient Older People's Housing*. Manchester Memoirs – Being The Memoirs and Proceedings of the Manchester Literary and Philosophical Society. 151: 20-32.

Mackenbach, J.P. & Borst, V. (1997). Heat-related mortality among nursing-home patients. *Lancet.* 349 (9061): 1297-1298.

Mavrogianni, A., Taylor, J., Davies, M., Thoua, C., & Kolm-Murray, J. (2015). Urban social housing resilience to excess summer heat. *Building Research & Information* (ahead-of-print). 1-18.

Mendes, A., Pereira, C., Mendes, D., Aguiar, L, Neves, P, Silva, A., Batterman, S. & Teixeira, J.P. (2013). Indoor air quality and thermal comfort—results of a pilot study in elderly care centers in Portugal. *J Toxicol Environ Health A.* 76(0): 333-344.

McHugh, I. & Keefe, G. (2012). *Adapting British Trimmings Extra Care Home in Leek, Final report for Design for Future Climate programme.* Manchester: Triangle Architects.

Neven, L., Walker, G., & Brown, S. (2015). Sustainable Thermal Technologies: Productive Alignment or Risky Investment? *Energy Policy*. 84: 195-203.

NHBC Foundation. (2012). *Understanding overheating – where to start: An introduction for house builders and designers*. Milton Keynes: NHBC Foundation.

Nicol, F., Hacker, J., Spires, B. and Davies, H. (2009). Suggestion for new approach to overheating diagnostics. *Building Research and Information* Vol 37 (4) 348-357

Office for National Statistics. (2014). National Population Projections, 2012-Based Projections Release.

Parsons, K. (2003). *Human Thermal Environments: The effects of hot, moderate and cold environments on human health, comfort and performance* (2nd ed.). London: Taylor & Francis.

Public Health England (PHE). (2014). *Heatwave Plan for England – Making the case: the impact of heat on health – now and in the future.* London: Department of Health.

Public Health England (PHE). (2015). Heatwave Plan for England: Protecting Health and Reducing Harm from severe heat and heatwaves. London: Department of Health.

Tregenza, P. & Wilson M. (2011). *Daylighting – Architecture and Lighting Design.* London and New York: Routledge.

van Hoof, J., Kort, HSM., Hensen, JLM., Duijnstee, MSH. and Rutten, PGS. (2010). Thermal comfort and the integrated design of homes for older people with dementia. *Building and Environment.* 45: 358-370.

Vardoulakis, S. and Heaviside, C. (2012) *Health effects of climate change in the UK 2012 – current evidence, recommendations and research gaps*. London: Health Protection Agency

Walker, G., Brown, S. &Neven, L. (2015). Thermal comfort in care homes: vulnerability, responsibility and 'thermal care'. *Building Research and Information.* 44(2): 135-146.

Wolf, J., Adger, W. N. and Lorenzoni, I. (2010). Waves and Cold Spells: An Analysis of Policy Response and Perceptions of Vulnerable Populations in the UK. *Environment and Planning A* 42: 2721-2734.

Zero Carbon Hub. (2014). *Overheating in homes – drivers of change.* London: Zero Carbon Hub.

Zero Carbon Hub. (2015). *Defining overheating: evidence review*. London: Zero Carbon Hub.

Zero Carbon Hub. (2016). *Next steps in defining overheating: a discussion paper*. London: Zero Carbon Hub.

11. Appendix A: Case study floor plans and location of data loggers

<<<INSERT APPENDIX A IMAGES HERE>>>

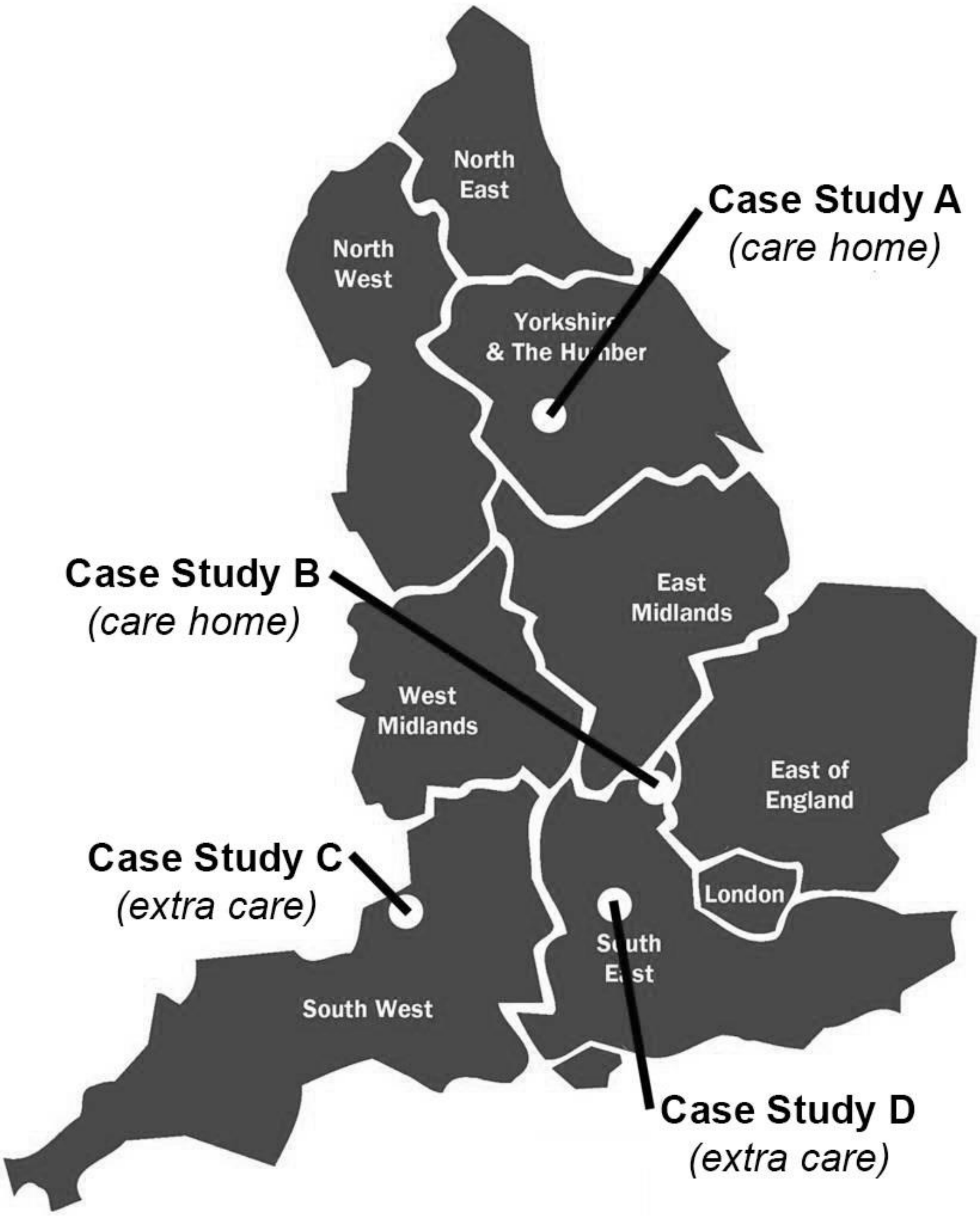
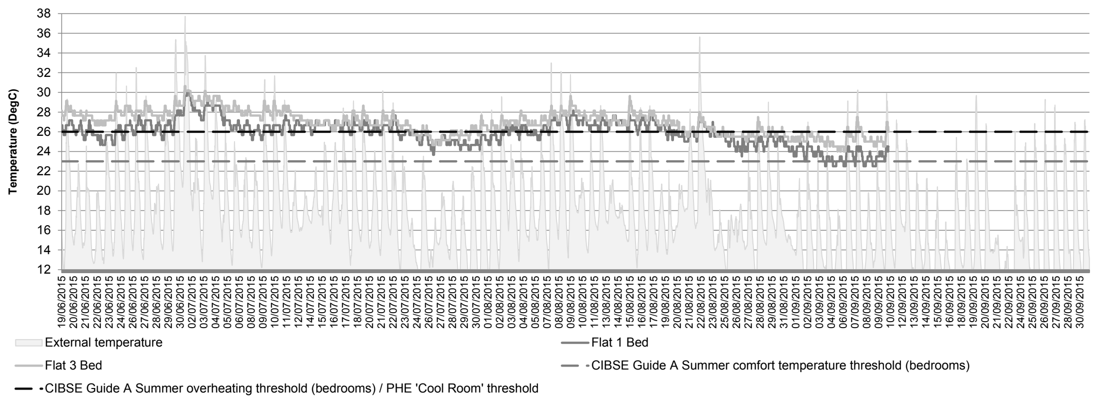
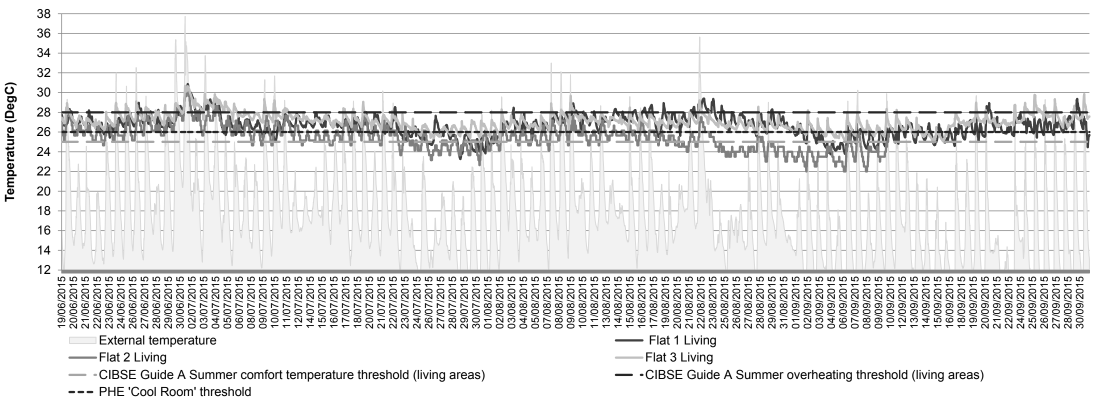


Figure 1 Locations of four case study buildings.

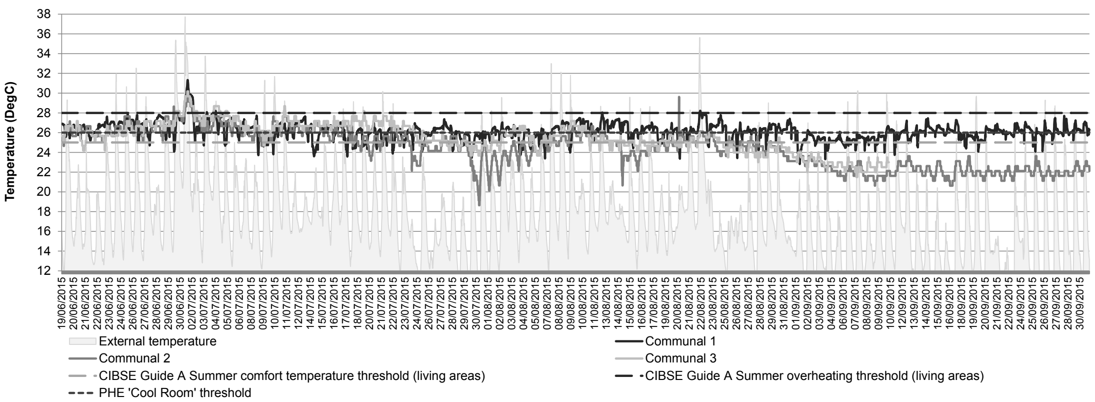
CASE STUDY D: Bedrooms



CASE STUDY D: Private living rooms



CASE STUDY D: Communal areas



CASE STUDY D: Offices

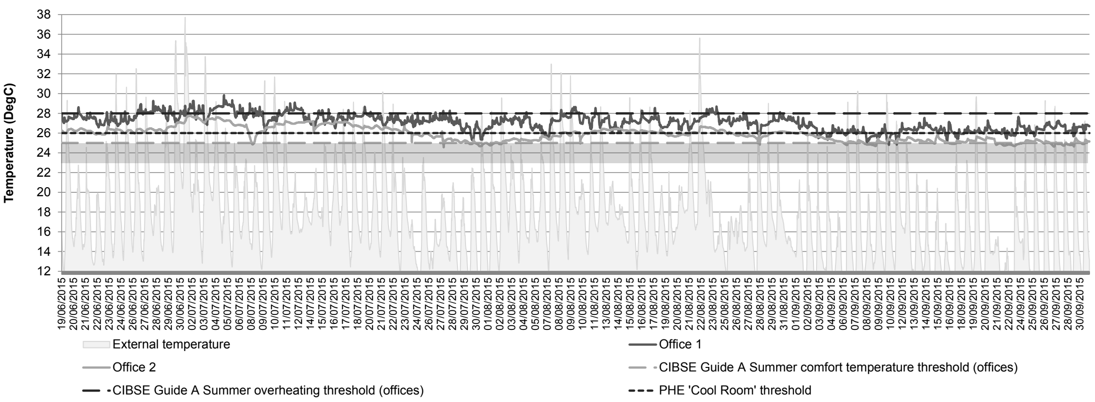


Figure 2 Indoor temperatures in monitored rooms in Case Study D (June-Sept 2015). Note: horizontal grey band in Offices graph indicates summer comfort temperature range for air-conditioned offices (Office 2 is air-conditioned).

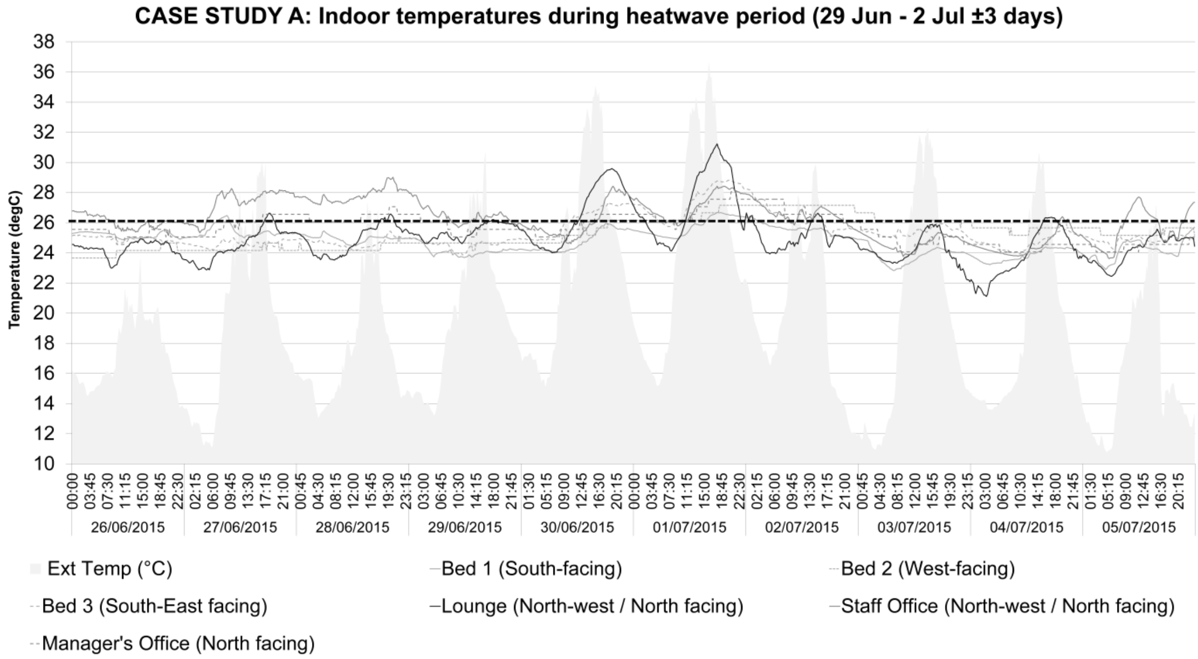


Figure 3 External and indoor temperatures in Case Study A during short-term heatwave period. Note: Dotted horizontal line outlines threshold temperature for PHE recommended 'cool areas' during heatwave period.

Figure 4 External shading design features in Case Study C include fixed brise soleil and overhanging eaves.

Figure 5 External shading design features in Case Study D include deep balconies.

Figure 6 Curtains in residents' room closed to reduce solar gain during the day.

Figure 7 Window restrictors placed on most windows, including ground floor (Case Study D).

Figure 8 Trickle-vents in windows closed during summer months in private residential flat in Case Study C.

Figure 9 Trickle-vents in windows painted closed in Case Study A.

Figure 10 Radiators covered to prevent access by residents in Case Study B.

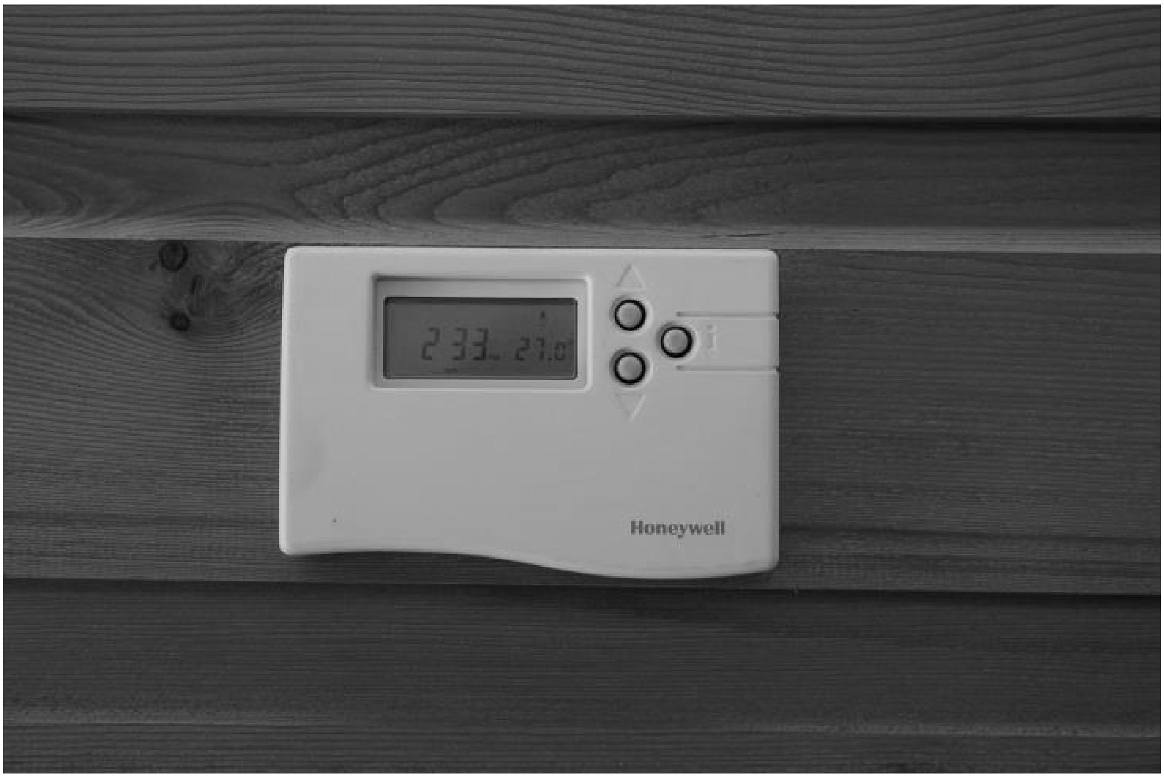


Figure 11 Thermostat in corridor set to 27°C in summer in Case Study C.

Table 1 Summary of characteristics of the four case study care settings.

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 RSL	Private company	Not-for-profit RSL	Not-for-profit RSL
Gross internal area (GIA) m^2	not-provided	820 (estimated)	4,823	5,500 (estimated)
No. of beds/dwellings	42 beds + 10 2-bed cottages	22 beds	50 flats	60 flats
Per cent of residents over 85 years	77%	64%	83%	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	Mixed mode: Natural ventilation with MVHR in residential, communal kitchen and sanitary areas and air conditioning in office
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

Table 2 Health and comfort related overheating assessment methods.

Source	Description
Health-related thresholds	
Met Office Heat-Health Watch Service 2015 (HHWS)	External temperature trigger thresholds (regional variations apply): Max external 30°C by day and min 15°C overnight for at least two consecutive days.
PHE Heatwave Plan for England guidance 2015(static)	Cool room/area indoor air temperatures ≤26°C *Implemented during heatwave period as defined by HHWS trigger thresholds.* Excess deaths may first become apparent at 24.5°C.
Housing Health and Safety Rating System (HHSRS) 2004(static)	Adverse health effects increase when external temperature >25°C.
World Health Organisation (WHO) 1987(static)	Health effects minimised in indoor air temperatures <24°C.
Thermal comfort-related thresholds	
CIBSE Guide A 2006 (static)	**Living areas/Offices:** 1% of occupied hours ≥28°C indoor operative temperature. **Bedrooms:** 1% of occupied hours ≥26°C indoor operative temperature.
TM52 2013 / CIBSE Guide A 2015 (based on BS EN 15251:2007) (adaptive)	**Individual rooms (free-running buildings):** Based on external and indoor operative temperatures during occupied hours. Two out of three criteria must be fulfilled for the room to be assessed as 'overheating'. Includes levels of occupant sensitivity.
PassivHaus Standard 2007 (static)	**Building:** 10% occupied hours ≥25°C indoor temperature.
SAP Appendix P 2012 (static)	**Building:** Significant risk if monthly mean indoor temperatures ≥23.5°C as modelled.

Table 3 Overheating criteria for the adaptive overheating method as outlined in CIBSE Guide A (2015) and CIBSE TM52 (2013).

Criterion	Description
Criterion 1: hours of exceedance:	The number of hours during which ΔT is greater than or equal to one degree (K) during the recommended period May to September (or available period) inclusive shall not be more than 3 per cent of occupied hours.
Criterion 2: daily weighted exceedance (W_e):	The time (hours and part hours) during which the operative temperature exceeds the specified range during the occupied hours, weighted by a factor that is a function depending on by how many degrees the range has been exceeded. W_e shall be ≤6 hours in any one day.
Criterion 3: upper limit temperature:	The absolute maximum value for the indoor operative temperature: ΔT shall not exceed 4K.

Table 4 Occupancy profiles for the monitored rooms for which data are available.

	Occupancy patterns
Case Study A	
Residential rooms	All bedrooms occupied by one person 24/7 with regular short visits by care staff.
Communal area	Lounge area generally occupied by approx. 20 occupants around meal times (7am-9pm); Mon-Sun.
Office areas	Staff office generally has 3 occupants, Mon-Fri, 8am-5pm. Manager's office has one occupant, Mon-Fri, 8am-5pm.
Case Study B	
Residential rooms	Two bedrooms (Bed 1 and 2) occupied by one person at night only (during day they are moved to communal area with constant care staff presence. One bedroom (Bed 3) occupied 24/7 by one person except at meal times and with regular short visits by care staff.
Communal area	Main Lounge (Lounge 1) generally occupied all day (7am-9pm; Mon-Sun) by approx. 10 persons. Secondary lounge (Lounge 2) generally occupied all day (7am-9pm; Mon-Sun) by approx. 10 persons.
Office areas	Staff office generally has 3 occupants, Mon-Fri, 8am-5pm. Manager's office has one occupant, Mon-Fri, 8am-5pm.
Case Study C	
Residential rooms	Flat 1 Living room rarely occupied as resident bed-bound; bedroom occupied 24/7 by one person plus regular short visits by care staff. Living rooms in Flats 2 and 3 generally occupied 8am-9pm by one person except for approx. 4 hours spent in communal areas/out of facility. Visits by family for approx. one hour per week (generally afternoon). Bedrooms in Flats 2 and 3 occupied 9pm to 8am by one person.
Communal area	Main Lounge (Lounge 1) generally occupied all day (7am-6pm; Mon-Sun) by approx. 20 persons. Secondary lounge (Lounge 2) in main circulation space so patterns unknown; estimated to be 5 persons max, 7am-6pm, Mon-Sun.
Office areas	Staff office generally has 3 occupants, Mon-Fri, 8am-5pm. Manager's office has one occupant, Mon-Fri, 8am-5pm.
Case Study D	
Residential rooms	Living rooms in flats generally occupied 8am-9pm by one person except for 1-2 hours per week when family visit (additional one person). Approx. 4 hours per day spent out of flat, but no set pattern.
Communal area	Main lounge (Lounge 1) generally occupied during evenings (4-9pm) by 15-20 people (Mon-Sun). Secondary lounge (Lounge 2) generally occupied during day (10am-4pm) by 2 persons (Mon-Sun). Dining area generally occupied during day (8am-7pm), with peak occupancy around meal times by 15-20 persons (Mon-Sun).
Office areas	Staff office generally has 2 occupants but no set daily pattern (hot desking). Manager's office generally has 2 occupants, Mon-Fri, 8am-5pm.

Table 5 Overheating results from monitoring of key rooms with case study buildings over summer period (June – September 2015).

	Indoor temperatures (°C)		CIBSE overheating guidance			Indoor temperatures (°C)		CIBSE overheating guidance	
	Average mean	**Maximum**	**Adaptive Approach (TM52 Criteria Failed)**	**Static Approach (% of occupied hours over temp. threshold)**		**Average mean**	**Maximum**	**Adaptive Approach (TM52 Criteria Failed)**	**Static Approach(% of occupied hours over temp. threshold)**
Case Study A					**Case Study B**				
Bed 1 (GF, S-facing)	24.7	**27.2**	n/a	**6.3**	Bed 1 (GF, NW-facing)	23.1	**28.1**	n/a	**7.9**
Bed 2 (GF, W-facing)	24.0	**28.0**	n/a	**2.7**	Bed 2 (FF, NE-facing)	23.0	**26.6**	n/a	**1.4**
Bed 3 FF, SE-facing)	23.8	**28.8**	n/a	**2.2**	Bed 3 (FF, SW-facing)	24.3	**29.8**	n/a	**16.7**
Communal (FF, N/NW-facing)	23.5	**31.2**	-	**1.0**	Communal 1 (GF, SW-facing)*	23.5	**30.3**	n/a	-
					Communal 2 (GF, NE-facing)	23.7	**26.7**	-	-
Office 1 (GF, NW/N-facing)	**26.4**	**30.1**	1	**1.6**	Office 1 (B, NW-facing)	24.8	**26.9**	-	-
Office 2 (GF, N-facing)	24.9	**28.1**	-	-	Office 2 (B, SW-facing)	24.9	**31.3**	**1, 2**	**14.6**
Case Study C					**Case Study D**				
Flat 1 (Bed) (GF, SW-facing)	24.7	**28.3**	n/a	**6.0**	Flat 1 (Bed) (FF, SE-facing)	25.9	**30.2**	n/a	**49.9**
Flat 1 (Living) (GF, SW-facing)	25.0	**29.1**	**1, 2, 3**	**1.4**	Flat 1 (Living) (FF, SE- facing)	**26.7**	**30.9**	1	**9.3**
Flat 2 (Bed) (FF, E-facing)	24.9	**29.6**	**n/a**	**24.1**	Flat 2 (Living) (SF, SE- facing)	25.4	**30.6**	1	**3.2**
Flat 2 (Living) (FF, E-facing)	24.4	**30.0**	**1, 2**	**1.0**	Flat 3 (Bed) (TF, SE- facing)	**26.9**	**30.6**	n/a	**76.0**
Flat 3 (Bed) (FF, W-facing)	24.0	**30.1**	n/a	**5.0**	Flat 3 (Living) (TF, SE- facing)	**27.1**	**30.7**	1	**17.6**
Flat 3 (Living) (FF, W-facing)	24.4	**29.4**	-	0.2					
Communal 1 (GF, S-facing)*	25.2	**28.4**	-	-	Communal 1 (UGF, SE/SW-facing)	**26.1**	**31.3**	**1, 3**	**1.1**
Communal 2 (GF, SE-facing)	25.8	**30.2**	1	**1.1**	Communal 2 (SF, NE-facing)	24.4	**29.6**	**1, 3**	**1.4**
					Communal 3 (LGF, NE-facing)	25.6	**30.2**	**1, 3**	**4.4**
Office (GF, NE-facing)	24.4	**28.7**	-	0.4	Office 1 (SF, SW-facing)	**27.1**	**29.8**	-	**4.1**
Office (GF, SE-facing)	**26.6**	**30.3**	1	**10.6**	Office 2 (LGF, no ext windows)*	25.9	**27.8**	n/a	-
Boxes shaded above indicate temperatures above PHE threshold temperature for cool rooms (26°C).			Boxes shaded above indicate overheating		Boxes shaded above indicate temperatures above PHE threshold temperature for cool rooms (26°C).			Boxes shaded above indicate overheating	

Notes: B=Basement; LGF=Lower Ground Floor; UGF=Upper Ground Floor; GF=Ground Floor; FF=First Floor; SF=Second Floor; TF=Third Floor; S=South; SE=South-east; SW=South-west; N=North; NE=North-east; NW=North-west; E=East; W=West.
* Case Study C Communal 1 and Case Study D Office 2 both have air-conditioning installed and as such were not assessed using either the adaptive or static approaches, as recommended in

CIBSE guidance.

Table 6 Assessment of design features of the case study buildings in relation to their potential impact on overheating risk.

	Positive characteristics (aspects that can help mitigate overheating risk)	**Negative characteristics (aspects that can help exacerbate overheating risk)**
Case Study A	+ Enclosed courtyard with green cover and shrubbery. + Office areas (high internal gains) face in northerly orientation. + Heavyweight materials used in construction.* + Balconies on some southerly-facing rooms provide shading to rooms below. + Internal blinds and curtains present in most rooms. + Openable windows in corridors to enable cross-ventilation. + Low energy light fittings. + Simple heating controls (thermostatic radiator valves (TRVs) at top of radiator)	- Communal heating and hot water system with distribution pipework throughout building. - Low reflective roof (low albedo). - Single aspect bedrooms. - Trickle vents painted over (maintenance issue). - Window restrictors present; no control on balcony doors (open or shut only).
Case Study B	+ Enclosed garden area with significant green cover, planting and mature trees. + Relatively heavyweight wall and floor materials used. + Internal blinds and curtains present in most rooms. + Low energy light fittings. + Simple heating controls present (only TRVs in rooms).	- Communal heating and hot water system with distribution pipework throughout building. - Heavy sash windows difficult to open, with little fine control. - Non-reflective roof (low albedo). - Single aspect rooms.
Case Study C	+ Secure green space around building with low shrubbery, and minimal hard paving. + Where large areas of hard paving are present, it is northerly facing. + Relatively heavyweight wall and floor materials used. + Internal blinds and curtains present in most rooms. + Brise-soleil (fixed louvres) and overhanging eaves to provide additional shading in the main south-facing communal area. + Low energy light fittings. + Openable windows in corridors to enable cross-ventilation. + Trickle vents and openable windows present in all rooms. + Simple heating controls present (zoned thermostats and individual radiator TRVs).	- TRVs at low level (poor accessibility for physically frail). - Communal heating and hot water system with distribution pipework throughout building. - Window restrictors present. - Low-reflective roof (low albedo). - Single aspect flats.
Case Study D	+ Balconies with vertical panels for shading + In-built planters on balconies for additional green cover. + Internal courtyard with raised planting beds (open to south west). + Mature tree retained on site (south west). + White roof (high albedo). + Heavyweight wall and floor materials used. + Internal blinds and curtains present in most rooms. + Low energy light fittings. + Openable windows in corridors to enable cross-ventilation. + Trickle vents and openable windows present in all rooms except one office.	- Communal heating and hot water system with distribution pipework throughout building. - Complex heating controls in residential flats. - Lever handles on windows not suitable for some residents with physical frailties (adaptations required). - Window restrictors present. - Single aspect flats. - Exposed carpark on west of site.

Notes:-
* Unless adequate overnight ventilation is provided, heavyweight materials can increase the night-time overheating risk as the materials may release heat captured during the day into the indoor spaces.

Table 7 Recommendations for stakeholders within the care sector to enhance preparedness against overheating risks.

Recommendations	Governmental Departments e.g. DoH; DCLG; DEFRA	Regulatory & Advisory Bodies e.g. CQC; PHE; CIBSE; Building Regulations (DCLG)	Care Providers	Design, Commissioning & Development Teams e.g. designers, contractors, care scheme providers	Maintenance & Management Teams	Care staff
Increase awareness of the current and future risks of climate change driven overheating in the care sector.	✓	✓	✓	✓	✓	✓
Promote mitigation of overheating in care settings by: • Monitoring temperatures especially during summer • Adopting localised heatwave plans, which apply PHE's guidance with a series of actions for the local site setting • On-going briefings and training for care staff to address the management of overheating risk both generally and within their specific setting.		✓	✓	✓	✓	✓
Support communication and greater clarity on the roles and responsibilities of differing staff in heatwaves in terms of the operation of heating and ventilation systems in care settings.			✓	✓	✓	✓
Ensure design of care facilities tackle the risk of overheating by promoting appropriate orientation, inclusion of thermal mass, shading (shutters and/or overhangs), cross-ventilation through more operable features, and deploy heating systems that avoid unwanted heat gains and enable effective heat management.		✓		✓	✓	
Develop and implement an overheating detection protocol for 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.	✓	✓				
Collaborate to harmonise and standardise health-related and building thermal comfort related overheating thresholds with a particular consideration of care settings.	✓	✓				
Consider integrating criteria on preparedness for current and future overheating into current care sector policies and inspection procedures.	✓	✓				
Share insights from case studies where heatwaves have been experienced and tackled with those involved in the design, management and use of care homes.	✓	✓	✓	✓	✓	✓
Notes:- *DoH=Department of Health; DCLG=Department of Communities and Local Government;*						

DEFRA=Department for Environment, Food and Rural Affairs; CQC=Care Quality Commission
PHE=Public Health England; CIBSE=Chartered Institution of Building Services Engineers.