Extreme Heat and Buildings: An Analysis of the 2021 Heat Dome Related Deaths in Community Housing in British Columbia

June 2022

Contents

Acknowledgements

BC Housing acknowledges that we deliver our services across the ancestral, traditional, and unceded homelands of hundreds of First Nations, each with their own unique histories, cultures, and traditions. We offer our commitment to working in good relations and to implementing the province's *Declaration on the Rights of Indigenous Peoples Act* (DRIPA) in all areas of our mandate.

This report was created at the request of the Board of Commissioners for BC Housing following the extreme heat event in Summer 2021. The BC Coroners Service report published on June 7 indicates 62 people died in SRO, social housing, and supportive housing sites. Of these sites, BC Housing funds 46 sites where 54 people died. The remaining 8 people died at other sites not funded by BC Housing. The majority of the 46 sites were located in the Lower Mainland.

We offer our sincere and heartfelt condolences to all those who lost loved ones or were injured during the heat dome of 2021.

Scope

This report focuses on sites across the community housing portfolio funded by BC Housing, which were identified by the BC Coroners Service as having at least one extreme heat related death during the Summer of 2021. The community housing portfolio includes sites managed by BC Housing directly, and by non-profit organizations. As a result, the scope of the analysis performed here excludes instances of extreme heat related illness or injury as well as other sites not funded by BC Housing.

Additionally, the scope of this report is on the buildings, surrounding environment, and adjacent operational practices. Other organizations, including the BC Centre for Disease Control (BCCDC) and health authorities, are examining the impacts of pre-existing conditions or other health impairments associated with the identified deaths[1]. While the BC Coroners Service matched addresses to identified heat-related deaths, no identifying information of residents was provided, including unit numbers. Therefore, this report does not include personal details of those residents who died.

Methodology

A high-level examination of the environmental circumstances and design of the 46 sites was performed, including the age of building, type of building material, location and surrounding physical spaces. Research has demonstrated that roofs, walls, and windows are conducive to high solar heat gains, depending on the type of material used. Other heat gains result from appliances and lighting (known as internal heat gains), and that information was also included where possible.

Information about operational practices was collected through surveys of BC Housing staff working on directly managed buildings (owned and operated by BC Housing). Due to the desire to maintain the confidentiality relating to the deaths as much as possible, only four[2] directly

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[1] See also Henderson, S.B., McLean, K.E., Lee, M.J., & Kosatsky, T. (2022) Analysis of community deaths during the catastrophic heat dome. *Environmental Epidemiology, 6*(1). [Analysis of community deaths during the catastrophic 2021 heat dome - PMC (nih.gov)]

[2] At the time the survey was conducted, only four directly managed BC Housing sites where heat-related deaths occurred were confirmed.

managed buildings were surveyed for the purposes of this report. While it is a small sample, when combined with existing research literature and best practices, it still provides a reasonable basis for some of the report's recommendations[3].

Limitations

The sites examined in this report were identified through the matching of addresses to a pre-existing list held by the BC Coroners Service of recorded deaths. No specific unit information was provided, and therefore it was not possible to identify specifics about the units inhabited by the deceased residents. Furthermore, out of the 46 sites, only seven are directly managed by BC Housing, and as a result some of the details about operational practices were not readily available.

Background

The province of British Columbia experienced extreme heat throughout the summer of 2021 with record-breaking temperatures observed across the province. The BC Coroners Service reported 619 heat related deaths between June 25 and July 1, 2021[4]. The BC Coroners Service considers a death heat related when:

- The localized environment or body temperature is keeping with hyperthermia (ICD10 T670); or
- There is no direct temperature at the time of death but there is evidence (circumstantial, scene environment, medical history) to support that heat played a significant causal effect on the death (ICD10 T679)[5]

Although much concern during the extreme heat event focused on those experiencing homelessness, the majority of all deaths recorded by the Coroners Service across the province occurred inside an individual's residence[6]. A residence is defined as "either [the] decedent's own or another's residence, hotels/motels, rooming houses, SRO (single room occupancy), shelters, social/supportive housing, seniors' homes, long term care facilities, nursing homes, etc."[7]

A total of 54 heat related deaths were recorded in BC Housing directly managed or non-profit managed community housing sites, or 9% of the total number of heat related deaths (619)[8] in B.C. As climate change will likely intensify future extreme heat events[9], there is a need to identify steps to mitigate heat and minimize its impact to residents of community housing so that future deaths can be avoided.

The following table provides the overview of where in province, heat related deaths occurred in community housing.

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[3] A joint BC Housing and BC Non-Profit Housing Association (BCNPHA) survey was conducted of non-profits across the province to determine extreme heat readiness. The results of that survey will inform how best to support non-profit housing operators going forward.
[4] extreme_heat_death_review_panel_report.pdf (gov.bc.ca)
[5] heat_related_deaths_in_bc_knowledge_update.pdf (gov.bc.ca)
[6] The BCCS reports that 98% of all heat-related deaths occurred indoors.
[7] Ibid.
[8] We are unable to report the percentage against total number of residents as our systems do not fully capture that information.
[9] Canada's Changing Climate Report in Light of the Latest Global Science Assessment

Municipality	Number of Deaths
Vancouver	20
Burnaby	12
New Westminster	7
Surrey	3
Kamloops	3
Duncan	2
Mission	2
Langley	1
Nanaimo	1
Penticton	1
Vernon	1
Victoria	1

Table 1: Number of deaths by municipality.

Reflecting that a high degree of urbanization creates an Urban Heat Island (UHI) effect, a larger number of deaths occurred in a larger urban centre. As Imran et al. (2018) explain, "the UHI occurs due to human modifications of surface properties by using construction materials with lower albedos and higher specific heat capacity (e.g., bitumen on roads), reductions in vegetated areas, the emission of anthropogenic heat (e.g., via air conditioning)" (p.2).[10] In addition to specific building information and individual behaviours, the UHI effect also raises considerations about the neighbourhood or community design and built environment as a whole.

Critical factor: Indoor temperature was the greatest predictor in heat-related deaths in spite of the individual characteristics of residents.

[10] Albedos are defined "as the proportion of light reflected from a surface". See [Albedo is a simple concept that plays complicated roles in climate and astronomy | PNAS]

Built Environment

While the outdoor environmental context to an extreme heat event is important, attention must be given to the buildings as people tend to remain indoors during extreme heat events, and as such the indoor temperature becomes paramount to ensuring resident health.

The building types where heat-related deaths occurred include multi-unit buildings that were 1-3 storeys, 4-7 storeys, 8 or more storeys, as well as purpose-built hotel buildings and rowhouses. The table below outlines the number of deaths per building type[11].

Building Type	Number of Deaths
Multi-unit: 1-3 Storeys	14
Multi-unit: 4-7 Storeys	12
Multi-unit: 8-24 Storeys	19
Hotel	5
Rowhouse	2
Other[12]	2

Table 2: Number of Deaths by Building Type

Building Characteristics by Type

Information about the built environment is provided below by building type, looking at key characteristics identified in the literature related to overheating in buildings. Those characteristics include age of building, ventilation and air distribution systems, window types and orientation, and construction type and exterior wall materials.

[11] Only six buildings are considered SROs: four of the buildings were one to three storeys tall; one was four to seven storeys tall; and one was eight or more storeys tall.

[12] Information as to the type of building for these sites is not readily available.

Age of Buildings

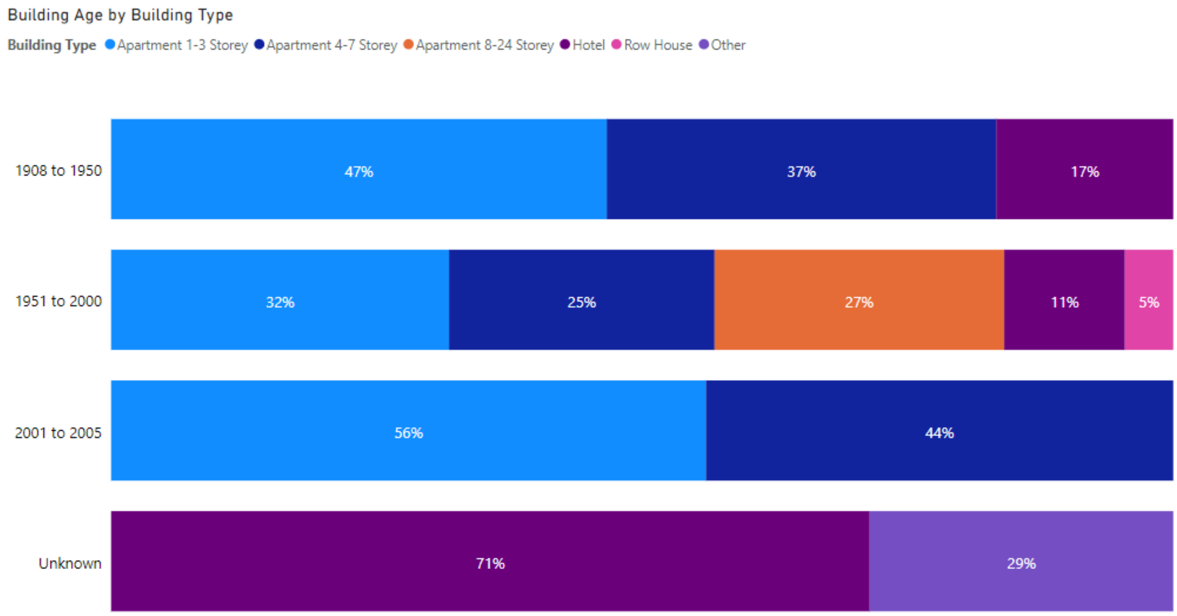

Figure 1: Building Age by Building Type

Based on the data available for the 46 sites, there is no distinct pattern related to the age of the building based on the date of construction. However, all of the buildings were older than 15 years and none were built under design guidelines that address energy efficiency and climate considerations.

As Figure 2 below indicates, although there have been upgrades to the roofing and exterior wall systems, it is unclear whether those upgrades incorporate passive cooling measures, namely high albedo materials and additional insulation in the top ceiling and roofing system. Due to the age of the buildings, windows upgrades included moving from single pane to double pane (which helps to mitigate heat gains)[13]. Other changes to the windows include the form of casing, in some cases moving from wood frames to aluminum or vinyl.

[13] No information about potential coatings on these windows were noted.

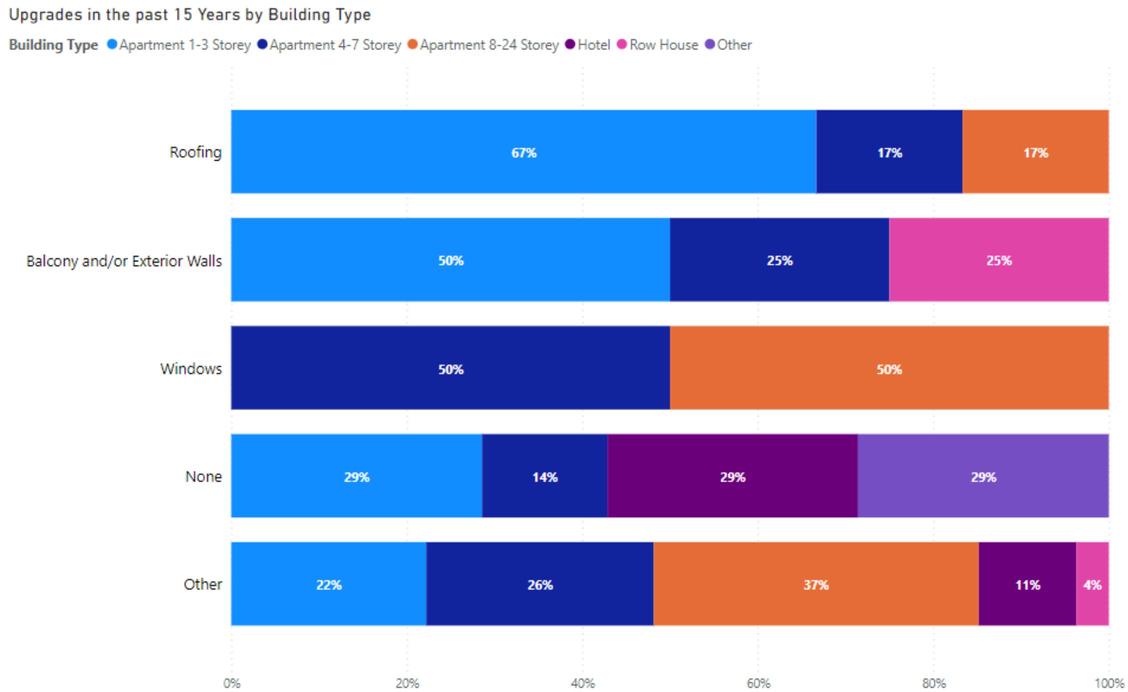

Figure 2: Forms of upgrades to selected buildings over the last 15 years

Ventilation and Air Distribution Systems

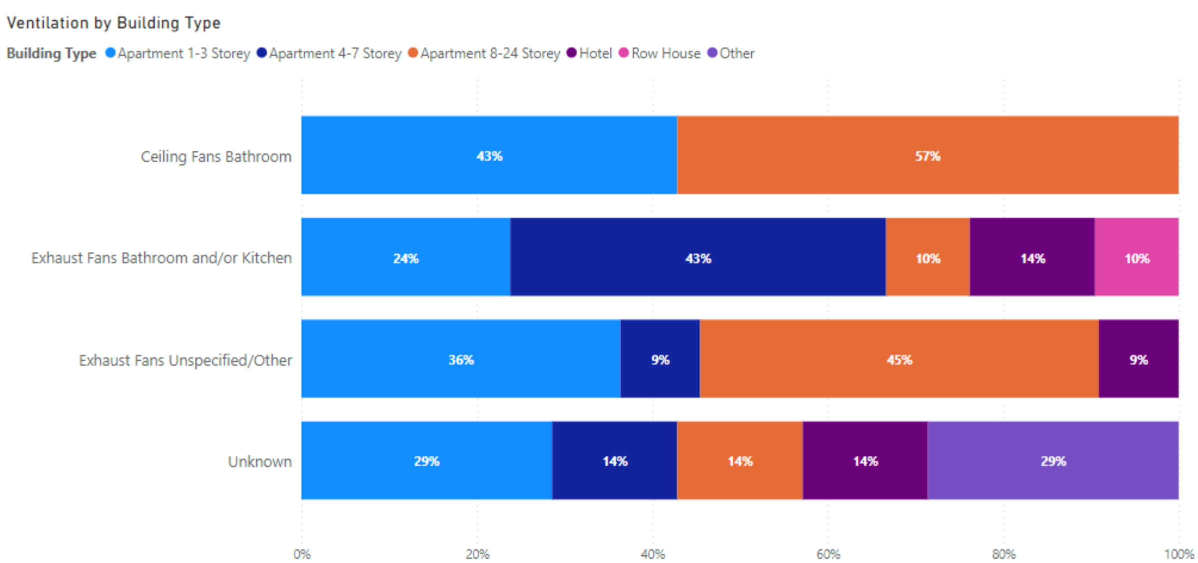

Figure 3: Forms of ventilation by building type

While most of the buildings had some form of ventilation in bathrooms and/or kitchens, these reflect base building code requirements and do provide cooling.

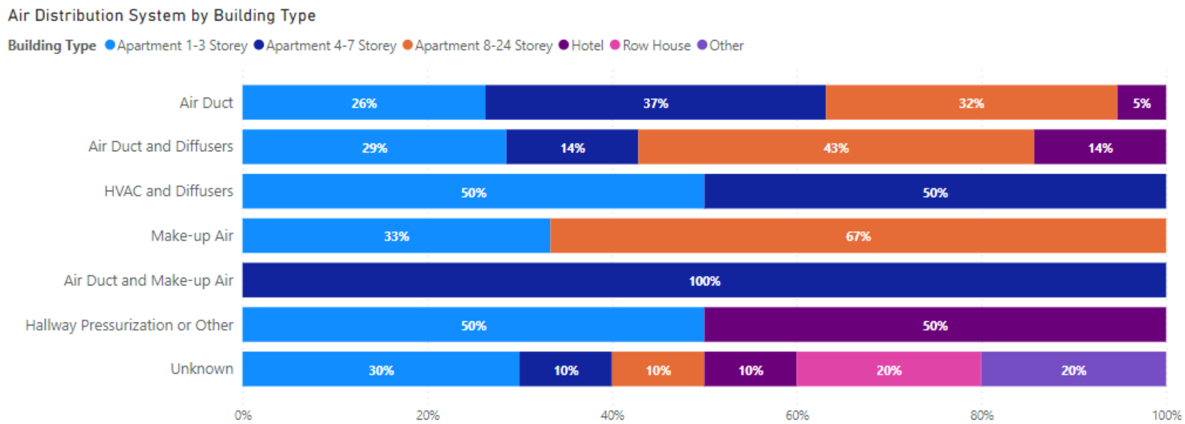

Figure 4: Air distribution systems by building type

As Figure 4 depicts, there is no standard form of air distribution system across a single building type. Based on available data for this report, it is unclear how effective each form of air distribution system was in providing cooling.

Windows

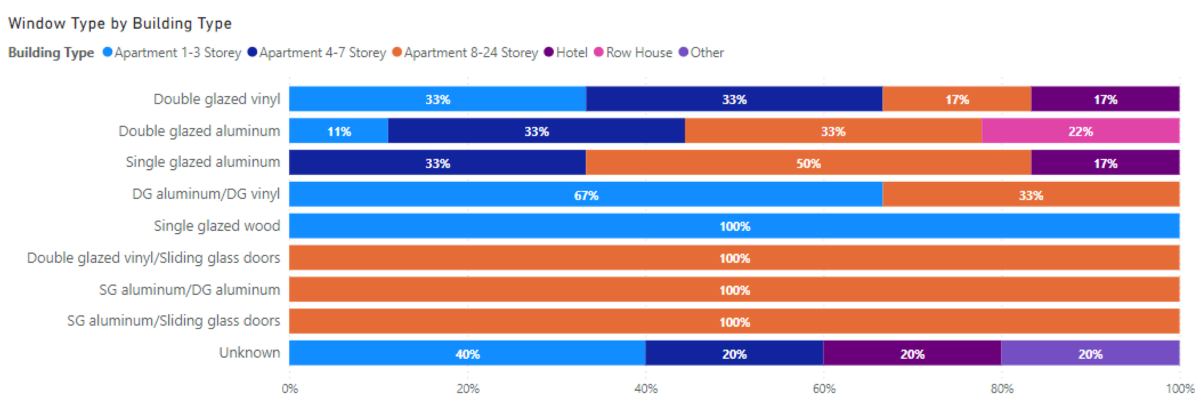

Figure 5: Window type by building type

The literature signals that all other things being equal, a window with more panes will mitigate heat gains more effectively. However, window coatings, window frames, and gas fillers (between the windowpanes) can make a significant difference. As Figure 5 demonstrates, a number of buildings still have single glazed windows, either with wood or aluminum casings. By itself, this is a concern due to the limitations that are known to exist for single glazed windows. However, the type of casing and its impact on cooling is less clear and would require more study.

Window type is not the only consideration when it comes to windows and cooling. The orientation of windows, available shading, and ability to open to allow for air flow are also critical variables to consider. There is no information about the windows in terms of ability to open adequately for air flow, but data relating to orientation and available shading structures is outlined below.

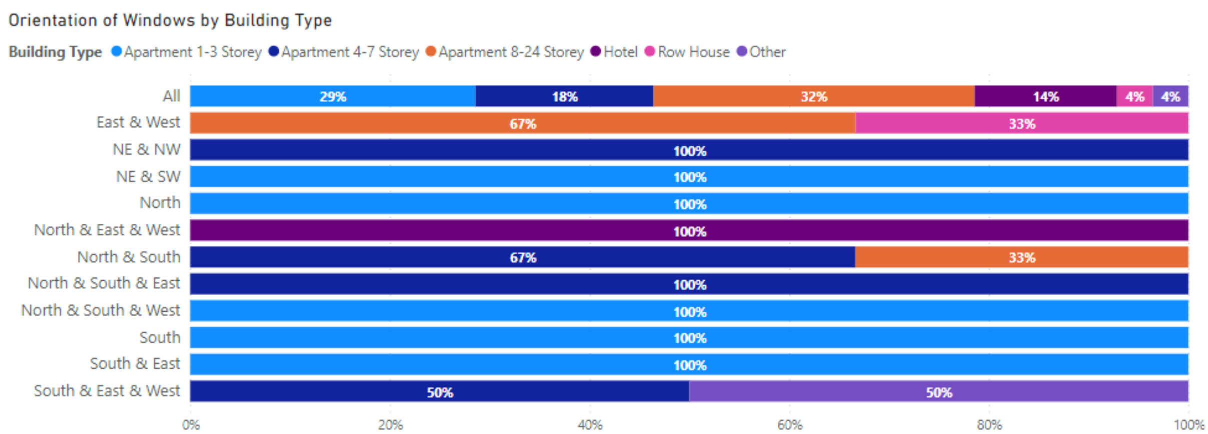

Figure 6: Orientation of windows by building type

As Figure 6 denotes, a considerable number of buildings of all types have orientations that are conducive to additional solar heat gains. Based on the literature, it is established that window coverings are instrumental in mitigating those gains, such as outside forms of shading (e.g., overhangs).

Based on the location of the 46 sites, a preliminary identification of shading by trees and other buildings was performed (see Figure 7 below). However, it is unclear from the data to what extent shading was available (e.g., number of storeys in a building; length of time shading was available, etc.). Figure 7 also highlights that nearly half of the buildings are without any form of shading from tees or other buildings, and therefore have no ability to mitigate solar heat gains through windows and exterior walls other than through the building construction itself.

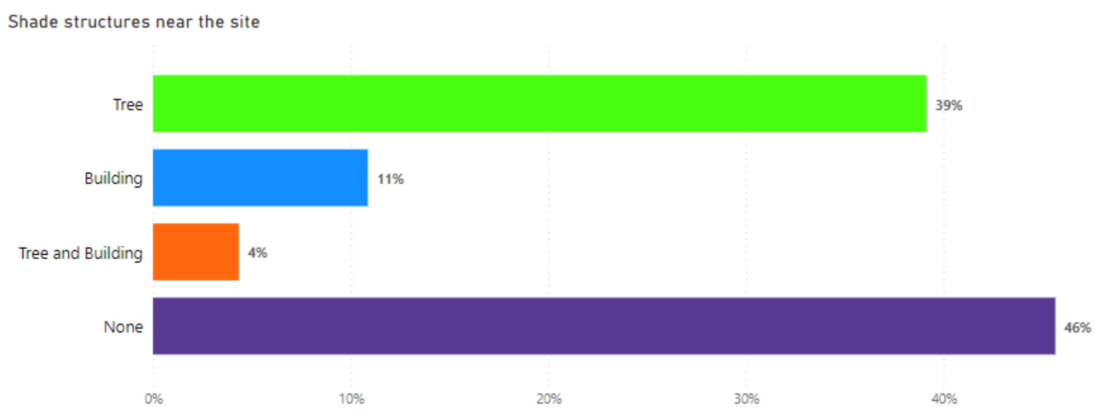

Figure 7: Shade structures near sites

Construction characteristics

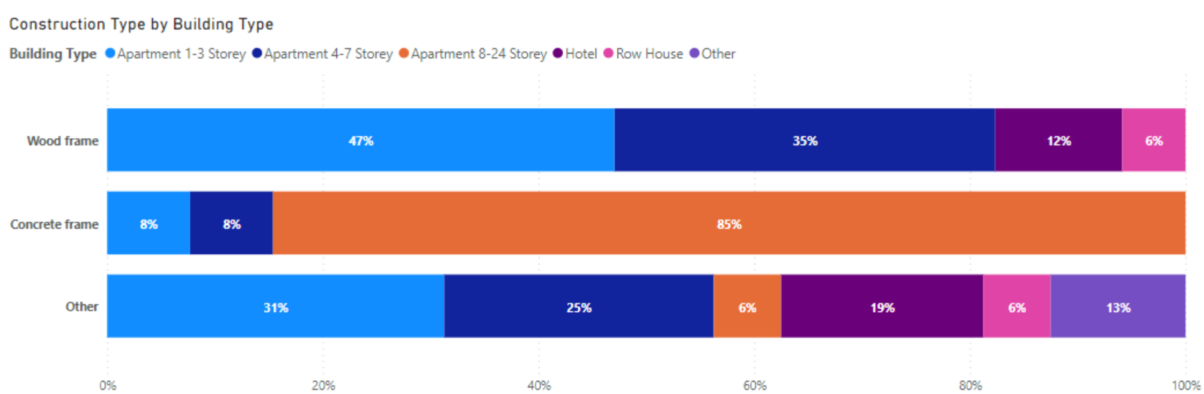

Figure 8: Construction type by building type

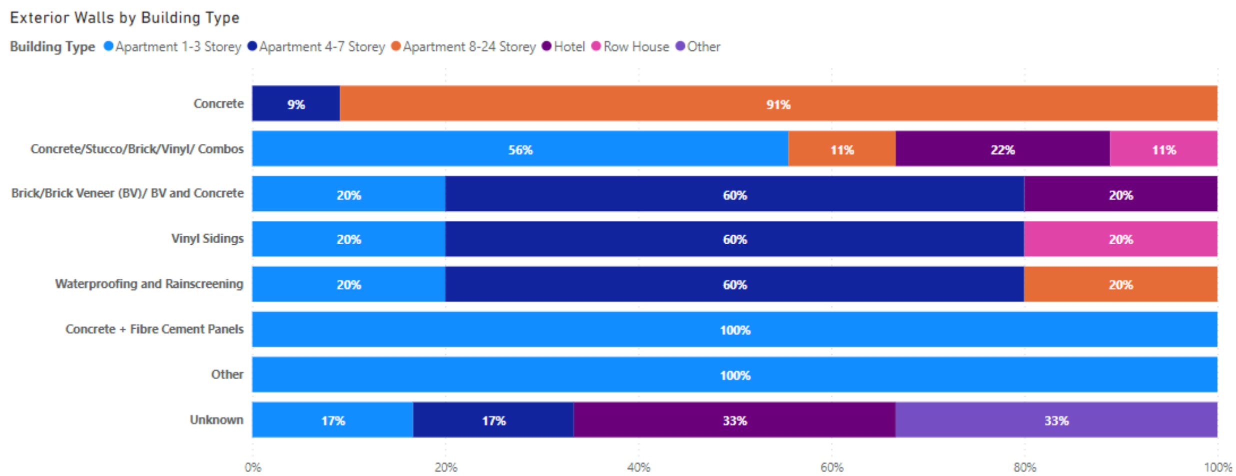

Figure 9: Form of exterior walls by building type

There is considerable diversity in construction type and wall assemblies. However, the greater consideration for any materials used for exterior walls and roofs is their level of albedo – looking at the extent to which they reflect or absorb heat, information not available in the data examined for this report. Further assessment is needed by individual building to determine that information and make specific recommendations for integration of cooling measures.

Findings

Based on the analysis above, conclusions can be drawn that the following measures are needed to ensure better cooling:

- With respect to windows, it does not appear to be dependent on building type but rather the window glazing (single vs double pane) and orientation, as well as opportunity for shading. It can be inferred that the age of the buildings may contribute more to the type of ventilation, air, and windows but without further assessment, this is not a foregone conclusion.
- The type of construction is likely to have less of an impact than the cladding materials. Most common across building types were brick, exposed or painted concrete and different forms of siding (e.g., vinyl and wood). Further analysis is required to determine if the painted surfaces or choice in siding resulted in higher or lower albedo.
- Air ventilation and air distribution systems are not maximized to provide passive cooling in individual thermal zones.

Key finding: There is no clear pattern that emerges about the building types. Rather, it is more about the components of the buildings themselves – windows, albedo levels of exterior walls and roofs, and ventilation/air distribution systems.

Implications

Buildings can contribute in two ways to heat gains during an extreme heat event: 1) through solar heat gains, and 2) internal heat gains. Solar heat gains occur through the building roof, walls, and windows whereas internal heat gains result from appliances and lighting. It is important to consider both means of heat gains when looking at potential interventions. It is also important to note that in multi-unit buildings, compared to single dwellings, the thermal zone – the level of analysis for the heat gain, is per apartment[14] and not the building as a whole. Therefore, considering specific characteristics of units in multi-unit buildings, such as window orientation, degree of shading, and ventilation opportunities is needed rather than assuming all interventions will work evenly across the entire building.

There are also two different approaches to cooling a building: passive and active. Passive cooling involves low energy usage and include roof insulation, ceiling insulation (for the top-floor ceiling), reflective (cool) roofing materials, reflective (cool) exterior paint or other wall material, interior blinds, exterior overhangs, window films (solar-controlled), and natural ventilation[15]. Active measures such as the use of air conditioning or ceiling fans have higher energy usage and are subject to fail if energy sources are no longer present (such as in the event of an electricity grid blackout). Active measures also contribute to higher heat ambient temperatures and, therefore, render such interventions less resilient in the long-term[16].

Controlling Solar Heat Gains

While a newer consideration perhaps in Canada, the use of various interventions to address extreme heat has been occurring in other regions such as the UK, Europe, Australia, and the United States where heat-related deaths due to extreme heat have been a significant challenge for years. Numerous studies exist that look at different ways of adapting existing buildings in this context, as well as different methodologies to study and model their effectiveness at cooling buildings.

Some of the interventions and the degree of importance may also need to account for resident usage. For example, closing internal window blinds will improve the cooling of the unit once outside temperatures meet a certain threshold, but this will depend on the resident being able to close their blinds, assuming there are adequate blinds for them to do so. Also, keeping windows closed during the day but opening them at night for increased ventilation[17] can be a successful intervention. However, this assumes that the windows are operable such that they can open, and that opening the window does not create other hazards, such as letting in noxious air due to wildfires, or decrease the security of the unit (as may be a concern for those in ground level units). Passive sharing options, such as using window film or exterior shutters/fixed overhangs are less dependent on resident action. These measures may be particularly more important for windows oriented south and receive more solar heat than other window orientations.

Certain passive measures involve expensive retrofits and may need to be integrated into capital maintenance plans and budgets over a longer period of time. One such measure is adding roof

[14] Sun, Zhang, Zeng, Levinson, Wei, & Hong (2021).
[15] Ibid.
[16] Williams, et al., (2019).
[17] Porritt, S.M., Shao, L., Cropper, P.C., & Goodier, C.I. (2010). Building orientation and occupancy patterns and their effect on interventions to reduce overheating in dwellings during heat waves. Proceedings of Conference: *IESD PhD Conference: Energy and Sustainable Development*, Institute of Energy and Sustainable Development, De Montfort University.

insulation and top floor ceiling insulation[18], or painting the exterior walls or roof lighter colours (thus increasing the albedo of the building)[19]. Adding fixed shading using overhangs may also be better suited for a building retrofit. Similarly, upgrading all windows as an additional passive cooling measure is also beneficial, particularly considering window orientation[20]. It is recommended from the literature that such measures be considered when looking at new developments, as the building can then avoid needing immediate interventions to address heat gains during extreme heat events[21].

Solar gains can also be mitigated through urban vegetation and the use of green roofs[22]. As Makido et al., (2019) explain, nature-based solutions (NBS) "emphasize human-nature relationships, planning for adaptation, and resilience in a way that benefits humans and enhances biodiversity. Such solutions cover a wide range of intervention approaches, including strictly green or combined green-grey infrastructure, ecosystem-based adaptation, and ecosystem-based risk management" (p.2). The benefit of NBS is that it works for both existing and new buildings, although it is understood that circumstances vary across neighbourhoods and cities, thereby rendering some of the solutions less effective depending on the environment and land-cover types. Although warranty providers may raise concerns with green roofs from a construction and warranty perspective, green roofs, as well as cool roofs (with reflective materials) are extremely efficient when the heat is at its highest during the day[23]. Cool roofs may also be more beneficial than green roofs across multiple land-cover types[24]. Vegetation is important in other ways as well. Increasing green infrastructure such as urban vegetation can also help mitigate the UHI urbanization effect by reducing the number of surfaces with lower albedos, while also offering more shading and evapotranspiration options[25], thus creating more citywide cooling.

Controlling Internal Heat Gains

Internal heat gains from appliances and lighting can be controlled by the adoption of low heat emitting appliances, especially those that run throughout the day and night, such as the fridge. Internal heat gains should also be a consideration for any cooling appliances such as fans and air conditioning units, to ensure that the measure adopted for cooling does not inadvertently make the indoor temperature worse for residents.

Key implication: Investment in passive cooling measures across all building types will best serve the goal of mitigating resident heat-related deaths and illnesses.

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[18] Sun et al. (2021).
[19] Porritt, S.M., Shao, L., Cropper, P.C., & Goodier, C.I. (2011). Adapting dwellings for heat waves. *Sustainable Cities and Society, 1*, 81-90. doi: 10.1016/j.scs.2011.02.004
[20] Rashid, M., Ahmad, T., Malik, A.M., & Ashraf, M.Z. (2016). Effects of orientation and glazing material on heat gain in semi-arid climate of Lahore. *Technical Journal, University of Engineering and Technology Taxila, 21*(4), 389-42.
[21] Porritt, et al. (2011); Sun, et al., (2021).
[22] Imran, Kala, Ng, & Muthukauaran. (2018); Makido, Hellman & Shandas, (2019).
[23] Imran, et al., (2018).
[24] Makido, et al., (2019).
[25] Makido, et al. (2019).

Operational Practices

With respect to the type of community housing, the majority of the deaths (41) occurred in social and seniors housing, followed by eight (8) in supportive housing where supports are not funded by BC Housing. Note that where supports are not funded by BC Housing, there is a limitation on ascertaining the exact nature of supports. Three deaths occurred in supportive housing with BC Housing funded supports, and only one death each in an emergency response centre (ERC) and permanent shelter respectively. The type of housing is important to note as it will inform what types of operational practices should be prioritized and tailored – in this case, where residents live independently and under a residential tenancy agreement.

A survey asking about operational practices during the heat dome period was sent to four sites which are directly managed by BC Housing. A broader survey about the non-profit sector's readiness for the extreme heat events has been conducted in collaboration with the BC Non-Profit Housing Association (BCNPHA) and the report will be ready later in 2022.

Identified Operational Practices

All four sites had cooling rooms available to residents and were observed to be used. Building management performed wellness checks on residents identified as most vulnerable[26] and reminded residents to use the cooling room as needed, provided fans when able, and ensured the residents had their own plans to remain cool. While the cooling rooms and fans were effective, more passive measures, may have helped create more cooling. For instance, there was no consistency observed or reported as to the use and type of interior blinds and it was noted that having interior blinds in the common room (as with other sites) would be beneficial. Adding more active measures such as air conditioning units in each unit was also suggested.

Findings

- Cooling rooms were made available but there is no data about the degree of usage by residents.
- Wellness checks were performed only once a day by BC Housing staff, and only with certain residents that were identified by staff as particularly vulnerable to heat. However, it is unclear how vulnerability was determined and if any residents who were being checked upon died during the extreme heat event (due to the limited information from the BC Coroners Service).
- Fans were made available to residents as requested.
- There is little information about the form of education provided to residents about the need to use their interior blinds to help cool their units.

Key finding: More support and resources for staff are needed to be heat-ready.

Implications

Extreme heat impacts human lives in numerous ways and the likely rise and intensity of extreme heat events across the province of British Columbia will require coordinated responses across

[26] It is unclear exactly how vulnerability was determined.

multiple agencies and sectors. While BC Housing continues to interface with other organizations to coordinate responses, this does not preclude taking action to best support residents, whether in directly managed buildings, or those being operated by non-profit housing providers in addition to built environment strategies.

In their study of the use of cooling centers to prevent in the United States, Widerynski et al., (n.d.)[27], they note that it is important to consider whether all low-income residents are in a position to use active measures of cooling, such as air conditioning, considering the cost associated in obtaining them and running them. As noted above, active cooling measures are also dependent on energy sources, something that can be negatively impacted during extreme heat or other weather events, rendering such measures moot.

Cooling centers are therefore a good alternative solution, as they provide a source of cooling without relying on individual capacity or ability to obtain cooling. Cooling rooms made available in the buildings where residents reside is a preferrable option, as it takes into account the risk of leaving the building and going outside into extreme temperatures and exposure, as well as barriers to leaving the building[28]. Widerynski, et al., (n.d.) define a cooling center or shelter as "a location, typically in an air-conditioned or cooled building that has been designated as a site to provide respite and safety during extreme heat" (p. 4). Studies examining the impact of cooling centers have confirmed that the existence of such measures can reduce mortality by approximately 66% compared to those who did not access an air-conditioned space (Widerynski, et al., n.d.). Therefore, even with the provision of fans in buildings without built in air conditioning, cooling rooms remain an effective way of reducing the likelihood of heat-related deaths and illness.

A cohesive heat plan is also an important factor. While cooling rooms can be a measure available within individual buildings, a heat plan will also ensure residents know such rooms are available and what other measures may be available (such as the ability to ask for fans, interior blind installation, air conditioning units). Ensuring there is clear information made available about the incoming extreme weather is also important, so residents are able to plan in advance. Education and heat awareness should be considered particularly for independent social and seniors housing where touch points between building managers and residents are less frequent.

With respect to operational considerations, it is important that all operators, whether it be BC Housing or non-profit be "heat-ready" and not assume that air conditioning meets that standard[29]. Black et al., (2013) concluded based on their study of seniors' residences in Australia, that heat-readiness also included having plans in place relating not just to cooling, but also to hydration, monitoring and emergency planning. They also underscored the importance of regular training for staff working with residents, in addition to building adaptation[30].

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[27] Widerynski, S., Schramm, P., Conlon, K., Noe, R., Grossman, E., Hawkings, M., Nayak, S., Roach, M., & Shipp Hilts, A. (n.d.). *The use of cooling centers to prevent heat-related illness: Summary of evidence and strategies for implementation*. Climate and Health Technical Report Series. Climate and Heath Program, Centers for Disease Control and Prevention.
[28] Transportation was a significant barrier to cooling centres identified by people with lived experience during the 2021 heat event. See Yumalugova, L., Okamoto, T., Crawford, E., & Klein, K. (2022). *Lived experience of extreme heat in B.C. Final report to the Climate Action Secretariat.*
[29] Black, D.A., Veitch, C., Wilson, L.A., Hansen, A. (2013). *Heat-ready: Heatwave awareness, preparedness and adaptive capacity in aged care facilities in three Australian states: New South Wales, Queensland and South Australia*, National Climate Change Adaptation Research Facility.
[30] Ibid.

Monitoring is a broader concept in this case then performing wellness checks. Assessing and monitoring indoor temperatures can also serve as helpful tools to ensure overheating does not occur in thermal zones, such as individual units. This is particularly important for those buildings that have high solar heat gains, even those who have been built to high energy efficiency standards[31]. Indoor thermal monitoring incorporated into building management tools can help identify units which exceed the threshold for healthy indoor temperatures without relying on resident involvement or behaviour, such as those who remain home for most of the day versus those who leave during the day.

Key implication: Heat-readiness requires planning, monitoring, and education for both staff and residents.

Conclusion

It is difficult with the limitations in the data available at this juncture to make clear determinations, other than to identify there are many opportunities available to introduce more measures to mitigate against heat-related deaths (and illnesses/injury) in community housing buildings of all types. Indoor temperature of homes is going to be a perpetual issue until all buildings across the portfolio have been properly fitted with passive and active measures. With respect to residents, it may also be concluded that heat-readiness plans are needed for both directly managed and non-profit buildings.

[31] Pathan, A., Mavrogianni, A., Summerfield, A., Oreszcyn, T., & Davies, M. (2017). Monitoring summer indoor overheating in the London housing stock. *Energy and Buildings, 141*(15), 361-378. doi: 10.1016/j.enbuild.2017.02.049.