Master's Thesis

The protective role of Urban Green Spaces during periods of heat for older adults vulnerable to heat stress: a case study in Groningen

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2024

Abstract

Climate change is causing an increase in hot days during summer in Europe. The Netherlands is no exception, and the average summer temperature and frequency of days warmer than 30º Celsius is increasing. People living in Urban Heat Islands (UHI's) are especially vulnerable for this. UHI's are urban areas that become warmer than their non-urban surroundings because of objects that retain heat, such as buildings and roads. An especially vulnerable group are older adults, a population group that is increasing in size over the coming decades. Without interventions, the burden of heat morbidity and mortality is expected to increase. A possible solution to this problem might be provided by Urban Green Spaces (UGS). These are green areas within an urban area, like parks and forests. Among other benefits, they provide coolness and create an opportunity to leave the house during periods of heat, which might protect vulnerable citizens from experiencing heat stress. By using semi-structured interviews, eight older adults vulnerable to heat stress in the city of Groningen have been interviewed. This study aims to explore what the protective role of UGS is for this group during periods of heat. It was found that the participants do relatively well during periods of heat. Most enjoy such warm days, although discomfort was mentioned simultaneously. Rather than going outside, most participants tend to stay inside during the hottest part of the day. Indoor temperatures were described as high by most participants, despite using sunshades and ventilators. They do not immediately associate UGS with coolness and expect to be more comfortable staying at home. Some participants do go to private green spaces like a vegetable – or communal garden during periods of heat. Such spaces appear to provide more shadow and privacy which are valued by these participants. To improve the adaptive capacity of older adults vulnerable to heat, it is recommended to further explore how features of private green spaces can be incorporated in public UGS.

Keywords: urban green spaces, older adults, heat stress, urban heat island-effect

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1. Introduction

Climate change is posing new risks and challenges for places all over the world. A warmer climate will result in more extreme weather than societies are used to right now. This includes phenomena such as heat waves, excessive rainfall and floodings. These events could lead to a wide array of problems. Over the last couple of years, an increase has been observed in such extreme events in Europe already (Kron et al., 2019).

An example of this is the increased occurrence of heat waves, and then particularly when cities are affected. Over the last couple of years, new research has shown the detrimental effects of 'Urban Heat Islands' (Ward et al., 2016), or UHI's. UHI's are urban areas that tend to become a lot warmer than the surrounding non-urban areas due to impermeable surfaces such as buildings, roads and pavements. This phenomenon occurs in most urban areas. It can lead to various issues for the city as a whole and for individuals. Examples are increased air pollution, increased energy demand, a lack of concentration, decreased productivity, exhaustion, dehydration, circulatory disorder, decreased sleep quality and it could even lead to death, as various studies have shown (Gabriel & Endlicher, 2011; Kovats & Hajat, 2008; Arbuthnott & Hajat, 2017). Because of the quickly fore shredding global warming, the effects of this phenomenon become increasingly worse. Especially in Europe, average temperatures rise faster and heat waves start to occur more frequently than in any other part of the world (Rousi et al., 2022). Besides, these heatwaves are expected to become more intense and longer too (Meehl & Tebaldi, 2004). This causes the UHI-effect to become a more serious concern in urban planning in more temperate European climates as well, such as in the Netherlands. If the emission of greenhouse gases continues at the same level as now, temperatures of 50º Celsius will become possible in the Netherlands in the year 2100 (KNMI, 2023).

An especially vulnerable group regarding heat stress are older adults, especially those over 80 years old (Åström et al., 2019). In 2021 this group consisted out of 800.000 people in the Netherlands, but this is expected to increase to 1,5-2,6 million people in 2050 (CBS, 2021). The share of people older than 65 will be 24,7% in 2050, compared to 19,8% in 2021 (PVL/CBS, 2022). A substantial part of this group will live in cities according to this same report. The 10 largest municipalities of the Netherlands will all face a population growth of people over 65 years old. The number of inhabitants from this group in 2050 is expected to be doubled in 2050 compared to 2005 in e.g. Utrecht and Groningen. With the growth of the number of older adults, the prevalence of age-associated diseases is on the rise as well (Suzman et al., 2015). Some of these diseases also increase the vulnerability to heat, such as cardiovascular disease, type 2 diabetes and obesity (Bouchama et al., 2007; Kenny et al., 2010).

The combination of a warming climate, an ageing (urban) population and the resulting increase in age-associated diseases in the Netherlands creates the need to explore the possibilities of reducing heat stress, especially among older adults. During the summer of 2022, a total of 469 people died because of heat in the Netherlands, or 27 deaths per million inhabitants (Ballester et al., 2023). This is a limited number compared to Italy's 295 deaths per million inhabitants and Spain's 280 respectively, but without interventions it can be expected that increasingly more people will die of heat stress in the Netherlands as well (Ballester et al., 2023).

Various interventions can be implemented to reduce the societal risks of heat. Examples include a change in urban design and in land use, targeted warnings, community-based programs and education about the risks of heat waves and heat stress (Wilhelmi & Hayden, 2010). A possible contribution to all these points could be provided by Urban Green Spaces, or UGS. Numerous studies have proven UGS' capacity to reduce the UHI-effect (Oliveira et al., 2011; Aram et al., 2019). Besides that, visiting UGS also results in psychological and physical health benefits, which in turn can make citizens more resilient to heat stress (Lachowycz & Jones, 2013). UGS provide the opportunity for physical activity and for social interaction, which are both important for older adults' health and well-being (Enssle & Kabisch, 2020). Additionally, UGS can be a refuge against heat stress for especially those living in UHI's. UGS can encompass various shapes and sizes, such as small local parks, large urban parks, urban forests, urban gardens, green roofs, green facades, and street trees, and both cooling -, well-being - and health effects occur already in relatively small UGS, however large UGS are more effective than small UGS (Aram et al., 2019; Reyes-Riveros et al., 2021). Cooling effects are not only present at the urban green space-site itself, but also extent towards streets in the vicinity of the UGS, according to Oliveira et al. (2011). They found that many shaded areas in an urban green space, a lot of evapotranspiration within it and a densely built-up area surrounding the urban green space all increase the cooling effect of an urban green space. Summarized, UGS can be considered a refuge for urban residents during periods of (extreme) heat because of its cooler environment and positive impact on physical and mental health.

Research on the adaptive capacity of households to adapt to urban heat is scarce, especially among older adults, while morbidity and mortality risks for this group are the highest for this part of the population during periods of heat (Mees et al., 2015; Ballester et al., 2023). For the population as a whole, various studies have shown that UGS can improve people's health and well-being during periods of heat by providing better thermal comfort than other urban areas (Lafortezza et al., 2009; Wang et al., 2017). Some studies have looked at the behavior and coping mechanisms of older adults during heat periods, such as Arnberger et al. (2017) in Austria and Malmquist et al. (2022) in Sweden. They both found that some older adults can cope with extreme heat easily, while others suffer majorly. Both studies found that a subgroup of the elderly population mainly copes by going outside of their house, mainly to UGS (Arnberger et al., 2017). This is generally the healthier and more active group. But another group mainly copes by staying inside, often in apartments that can get very hot and hotter than places outside such as UGS. For this group, visiting UGS during heat periods could possibly improve their well-being and reduce mortality and morbidity risks if it leads to a reduced exposure to heat.

Kabisch et al. (2015) argue in their systematic review that research on specifically elderly people's green space use is scarce, worldwide. Also in the Netherlands, research on UGS use among older adults is scarce, especially during periods of heat, while understanding this phenomenon better could result in more optimized urban planning and thus in reduced morbidity and mortality risks for the urban population. Especially the group of older adults with a poorer health, a low adaptive capacity to heat and high levels of exposure is at risk for negative effects of heat periods and could benefit from visiting UGS (Arnberger et al., 2017). Yet, various studies have indicated that specifically this group of older adults uses staying inside as a coping mechanism more often (Mees et al., 2015; Wanka et al., 2014). Especially social isolation and a lack of financial – and health resources is associated with a lower probability to visit UGS during periods of heat (Arnberger et al., 2017). Visiting UGS during heat periods could be an effective strategy to prevent heat morbidity and mortality in this group (Arnberger et al., 2017). Finding out what prevents these people form visiting UGS during heat periods can be of great importance for urban planners. Why would having a poor health result in visiting UGS less frequently, while staying inside the house often is worse for someone's health? And for older adults that do visit UGS, what do these spaces mean for them during periods of heat and what attracts them to do so? Using surveys, research has already been done on UGS use during periods of heat among all ages (Lafortezza et al., 2009). Additionally, Arnberger et al. (2017) have done research on older adults' behavior during periods of heat and how often they choose to visit UGS. Yet, a study focusing on people's motivations for their behavior during periods of heat and the role of UGS is still lacking. Additionally, motivations for UGS use differ between cultures and contexts (Lachowycz & Jones, 2012). Such a study has not been done before in the Dutch context and it would be insightful to gain a better understanding into how and why older adults living in a city use or not use UGS during periods of heat as a protective measure. Therefore, this study aims to entangle in-depth the relationship between vulnerable older adults and their UGS use motivations during periods of heat in Groningen. To answer this question, first the extent of experienced heat stress among this group will be studied. Secondly, there will be looked at what coping mechanisms this group uses to deal with this heat, including visiting UGS.

Research question: What is the protective role of Urban Green Spaces during periods of heat for older adults vulnerable to heat stress in Groningen?

Sub-questions:

- What is the association between sensitivity -, exposure – and adaptive capacity to heat and experiencing heat stress?
- What different coping mechanisms are employed by older adults vulnerable to heat stress during periods of heat?

2. Theoretical framework

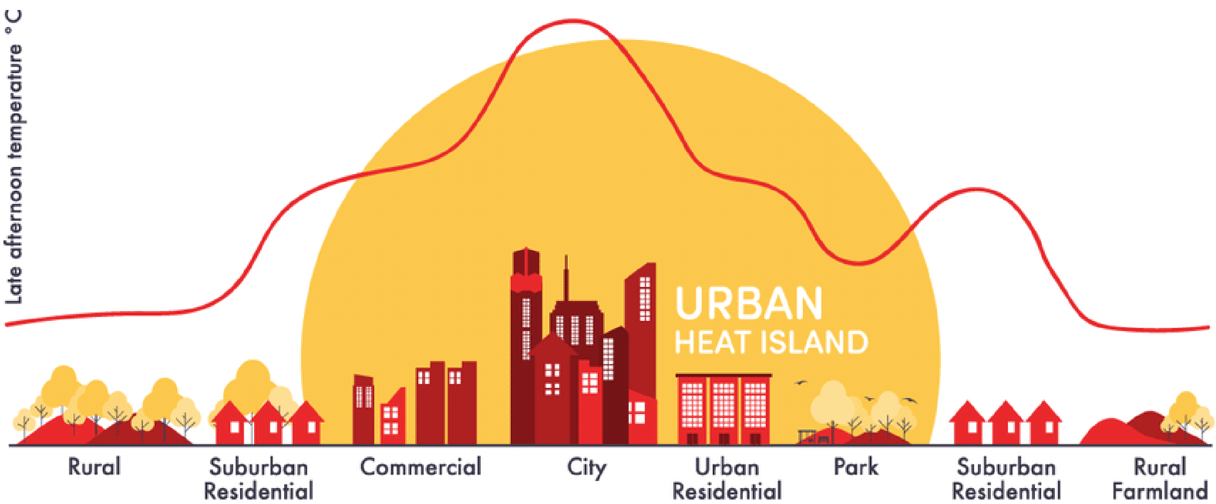
2.1 The Urban Heat Island-effect

In 2023, 56% of the global population lives in cities, generating 80% of the total global GDP (World Bank, 2023). In 2050, it is expected that around 70% of the global population is living in cities. This results in various challenges, one of them being the Urban Heat Island-effect. The Urban Heat Island-effect, or UHI-effect in short, refers to the phenomenon that the urban air temperature is higher than that of the surrounding rural environment (Kleerekooper et al., 2012). According to Oke (1987), the following causes together create this effect:

1. Absorption of short-wave radiation from the sun by low-reflective materials and trapping of this radiation by multiple reflections between buildings and street surface.
2. Air pollution within the urban environment that absorbs and re-emits long-wave radiation back to the urban environment.
3. Obstruction of the sky preventing long-wave radiation to radiate back to the sky. Heat gets intercepted and will be re-emitted to the urban environment.
4. Anthropogenic heat is released by combustion processes such as traffic, building heating/cooling and industries.
5. Increased heat storage by buildings with large thermal capacities. Besides that, the urban environment has more surface area than the rural environment and can therefore store more heat.
6. The possibility of evaporation is decreased because of ‘waterproof surfaces’ such as streets, pavements and roofs. Consequently, more energy is put into sensible heat rather than latent heat.
7. The reduction of wind speeds prevents heat from mixing with cooler layers of air.

The combination of the factors above together creates the UHI-effect and reinforce each other. For example, more absorption of heat by buildings will create more cooling demand, which in turn increases the amount of anthropogenic heat released (Mohajerani et al., 2017). In general, the result of this UHI-effect is that urban environments both get hotter during the day and less easily loose this heat during the evening and the night than more rural areas (Heaviside et al., 2017). Recent studies have shown that the average UHI-effect ranges between 5 and 15°C (Santamouris, 2013). The figure below illustrates how temperatures are higher in more urbanized areas.

Figure 1: Visualization of the UHI-effect within an urban area



Source: World Meteorological Organization, 2021.

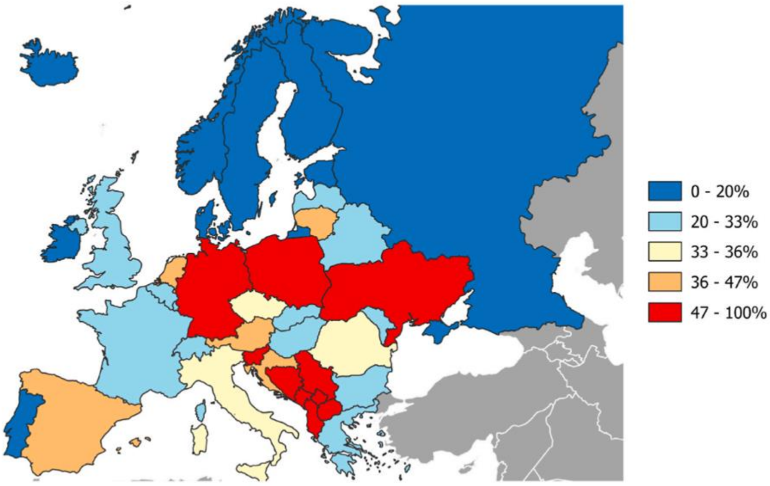
Urban heat is not distributed evenly in a city. Microclimates can occur and the climatologic circumstances can vary greatly even over short distances (Heaviside et al., 2017). In general, the more of the seven factors contributing to the UHI-effect as described by Oke (1987) are present, the more intense the UHI-effect can be expected to be. Besides that, geographic features, climatic conditions and seasonal variations of a particular city are all influencing the intensity of the UHI-effect (Mohajerani et al., 2017). It should be noted that a large UHI does not necessarily imply urban heat problems as well. This is mainly because the UHI-effect only measures the difference between an urban area and its immediate rural surroundings. For instance, according to Ward et al. (2016), the UHI-effect in Hamburg is a lot higher than in Madrid. This does not mean that the problems with urban heat are less present in Madrid. Martilli et al. (2020) hence argue that in terms of the need (or not) for heat mitigation strategies, it is important to look at the ‘absolute’ urban thermal climate and its departure from comfortable conditions. Nevertheless, in the scientific literature the concept of ‘Urban Heat Island-effect’ is often interchangeably used with concepts such as ‘urban heat stress’ or ‘urban thermal discomfort’.

2.2 Urban Heat Stress

2.2.1 What are the effects of urban heat stress?

Heat stress in individuals occurs when the combination of air temperature, radiation, humidity and wind all interact in a way that causes the body temperature to rise (Motamedzade & Azari, 2006). Due to the UHI-effect, heat stress is more likely to occur in urban areas than in non-urban areas (Lafortezza et al., 2009). Heat stress can lead to a wide array of problems. Excessive heat is related to decreased productivity, decreased sleep quality, increased energy costs, increased air pollution levels, increased thermal stress on residents, a strong impact on urban ecosystems and even heat-related illnesses and increased mortality (Arbuthnott & Hajat, 2017; Mohajerani et al., 2017). Even though not all people who experience heat stress end up in the hospital, the consequences can still be significant. In European cities, high volumes of noise and traffic, atmospheric pollution and excess of built-up areas already contribute to a lower quality of life (EEA, 2005). Urban heat stress could cause further damage to the perceived quality of life of citizens. Especially in Europe, heat waves occur three to four times more frequently compared to similar latitudes in the Northern Hemisphere over the last 42 years (Rousi et al., 2022). Additionally, in North-Western Europe the hottest summer days are warming twice as fast as the mean temperature on summer days (Patterson, 2023). This is an additional risk for countries such as the Netherlands, since the threshold for heat mortality and morbidity is lower in cooler climates compared to warmer climates (Kovats & Hajat, 2008). This is also illustrated by the map below by Taylor et al. (2023). It shows that heat fatality cases are rising faster on average in the Netherlands than in e.g. Italy or France, where temperatures are higher on average.

Figure 2: The % increase in deaths (6 year moving average) attributable to heat amongst those over 65 in 2019 relative to 2005 baseline.

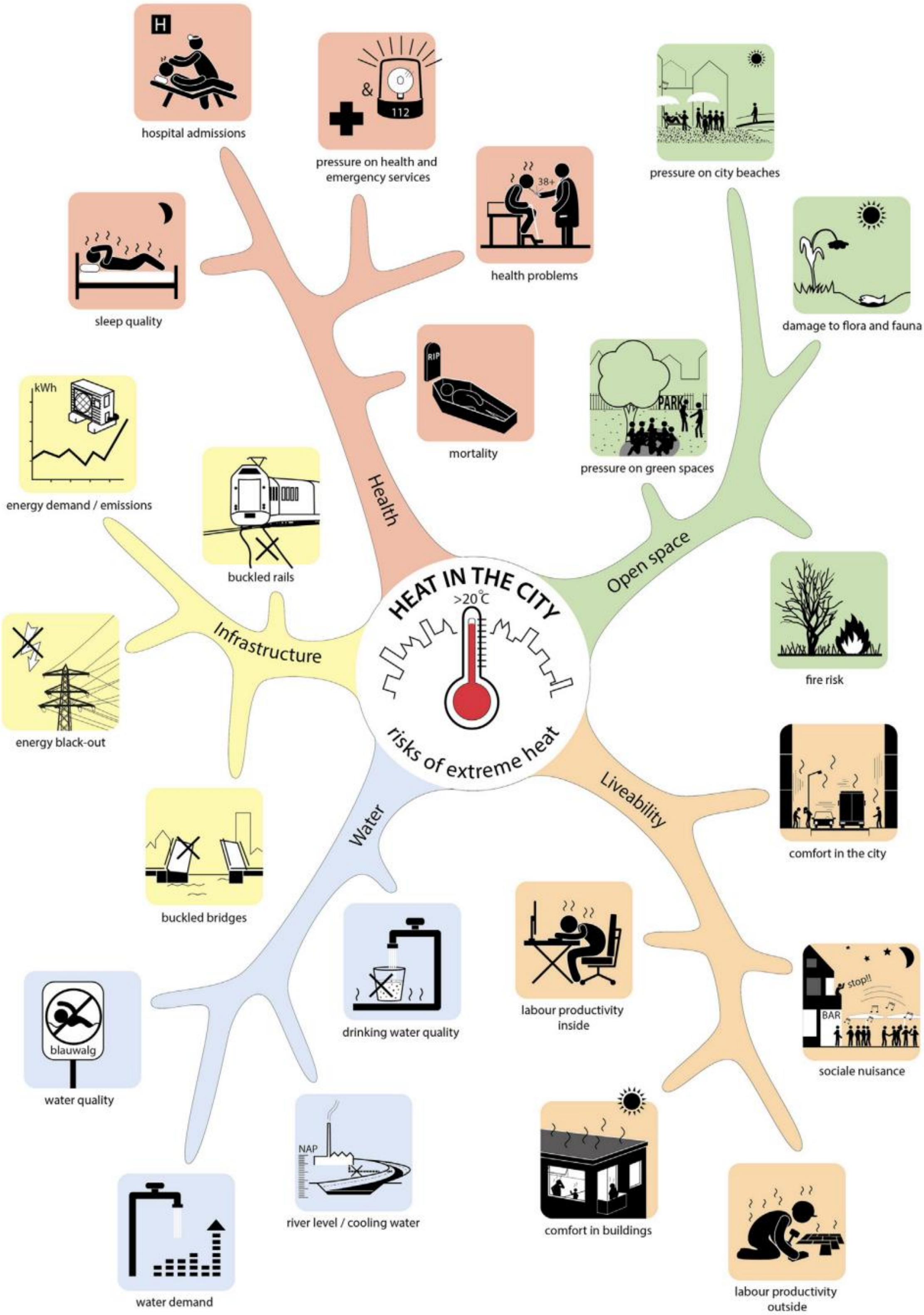


Source: Taylor et al. (2023)

The impact of heat on the health of individuals can be classified on a spectrum ranging from mild discomfort to life-threatening medical conditions (Dessai, 2002). Symptoms of heat stress include feelings of heat exhaustion, nausea, insomnia, irregular breathing and heartbeat/pulse and the worsening of pre-existing medical conditions and illnesses (Kalkstein & Greene, 1997). According to Burkart et al. (2021), in 2019 a total of 356,000 heat-related deaths occurred globally. In London, the 2003 heatwave caused a 40 percent higher mortality rate than could be expected without the heatwave. During the 1995 and 1976 London heatwaves, which were less severe, the mortality rates were respectively 16 and 15 percent higher than could be expected without the heat wave (Johnson et al., 2005). This shows that the severity of urban heat stress is important for the eventual mortality rate. Notwithstanding, health risks have shown to be significant at even moderately high temperatures (Gasparrini et al., 2015). Additionally, they found that in England as a whole emergency hospital admissions were not higher than usual during the heat wave, except for London. The same pattern was observed in France, Italy and Portugal during this heat wave (Lafortezza et al., 2009). In Paris, 14.802 people died in a 20-day period which could be attributed to the heatwave (Kovats & Hajat, 2003). Cities aggravate the effects of heatwaves. And additionally, climate change will aggravate the intensity of heat waves in the future (Hajat et al., 2014). People most at risk are the elderly and those who are socially or physically vulnerable (Kovats & Hajat, 2008). Their pre-existing conditions can be worsened by heat stress.

Besides health risks, urban heat can also cause risks for the open space, livability, water and infrastructure networks of a city (Klok & Kluck, 2018). The figure below by Klok & Kluck (2018) gives an overview specifically for the Netherlands of what these risks look like.

Figure 2: Risks of (extreme) heat in urban environments



Source: Klok & Kluck, (2018).

2.2.2 Vulnerability to heat stress

An especially vulnerable group regarding heat stress are older adults, especially those over 80 years old (Åström et al., 2019). When considering vulnerability to urban heat stress, three main determinants should be considered (Wilhelmi & Hayden, 2010): exposure, sensitivity and adaptive capacity.

This is due to a range of factors. Generally, as individuals age, their vulnerability to heat increases. With age, the physiological ability to maintain body core temperature during heat stress becomes compromised, also in otherwise healthy individuals (Inbar et al., 2004). Additionally, chronical diseases and medicine use are more common in this group. Especially cardiovascular disease, type 2 diabetes and obesity are known to be compounders regarding risks of heat-related illnesses (Bouchama et al., 2007; Kenny et al., 2010). These factors make an individual more sensitive to heat. Functional disabilities are also common among older adults, which makes them less capable of implementing measures or create options to avoid heat (Vandentorren et al., 2006). This makes them more vulnerable for exposure to heat. There is also a large group of older adults that is dependent on external care for their personal hygiene and their mobility. This group is highly dependent on access to sufficient care to be able to adapt to heat (Hansen et al., 2011). Besides that, they argue that older adults often live in social isolation and in low socio-economic circumstances. These are further factors increasing their vulnerability to heat stress. Poorer citizens are also less likely to be able to afford air conditioning, which could reduce their exposure and increase their adaptive capacity towards heat (Kemen et al., 2021). Living on the top floor and living in a flat instead of a house also increase mortality and morbidity risks (Naughton et al., 2002; Mirchandani et al., 1996). Besides the physical risks, heat stress can also increase anxiety, despair and worry among vulnerable older adults (Hansen et al., 2011). The most vulnerable of this group are those living in institutions, confined to bed or living alone (Belmin et al., 2007).

2.2.3 What factors contribute to urban heat stress?

Heat-related mortality and morbidity are the result of various natural and human stressors (Wilhelmi & Hayden, 2010). While meteorological conditions can create extreme heat events in urban environments, human stressors such as socio-economic inequality, building structures, personal characteristics and social networks can impact the ability of individuals and communities to respond to and cope with such events (Harlan et al., 2006). Considering all these different stressors, three main categories can be identified that together determine an individual's vulnerability to extreme urban heat: exposure, sensitivity and adaptive capacity (Wilhelmi & Hayden, 2010; Inostroza et al., 2016; Rathi et al., 2021). 'Vulnerability' can be defined as 'the degree to which a system is susceptible to injury, damage or harm'

(Smit et al., 2001). In this case, it represents the susceptibility of individuals within a specific community to injury, damage or harm caused by urban heat. Older adults in urban environments and specifically those living in urban heat islands can often be considered as vulnerable (Arnberger et al., 2017). Older adults frequently experience a heightened vulnerability to heat due to a combination of increased exposure, greater sensitivity, and reduced adaptive capacity compared to the broader population. This can possibly lead to heat stress. The three components of heat vulnerability are further explained below.

a.) Exposure

Exposure towards extreme heat conditions is one of the three contributors to heat vulnerability. It is constructed by the combination of housing conditions and the surrounding residential environment (Arnberger et al., 2017; Wilhelmi & Hayden, 2010). Together, these factors determine how much an individual is exposed to extreme heat conditions. Housing conditions can have a significant impact on how periods of heat are experienced. Arnberger et al. (2017) determine five factors that constitute the capability of an individual's housing condition to reduce the impact of heat periods. These are apartment size, the presence of air conditioning, the presence of a 'cool room' in the house, the experienced indoor temperature during a heat wave and the satisfaction with the apartment in general. All these factors contribute to the total exposure to heat, both in intensity and time.

Irrespective of an individual's housing condition, the source of extreme heat resides beyond these walls, namely in the surrounding environment. Wilhelmi & Hayden (2010) consider the intra-urban distribution of heat as the main cause of heat vulnerability, which is influenced by climate variability/heat waves and the urban land use/the UHI-effect. The changing climate will result in a warmer climate in general in Europe and more frequent and intense heat waves (Meehl & Tebaldi, 2004; KNMI, 2023). Besides that, many cities globally and in Europe are growing and without policy interventions, this will probably increase the UHI-effect in many cities (World Bank., 2023; Ward et al., 2016). This UHI-effect is not evenly distributed over a city, hence Wilhelmi & Hayden (2010) talk about the 'intra-urban distribution of heat' regarding extreme heat vulnerability. Moreover, global evidence indicates that individuals with lower socioeconomic status are disproportionately affected by UHI effects (Hsu et al., 2021; Heaviside et al., 2017; Chakraborty et al., 2019), skewing the intra-urban distribution of heat towards neighborhoods of lower socio-economic status. Measures to combat the UHI-effect in a city will immediately result in less exposure to extreme heat for its residents. It has been proven that not only urban green spaces are cooler than its surroundings, but even have the capacity to cool down the city in the vicinity of this urban green space (Oliveira et al., 2011).

For older adults, exposure to extreme heat is a larger risk than for most other people, irrespective of income level or geographical region (Ebi et al., 2021). As mentioned before, with age, the physiological ability to maintain body core temperature during heat stress becomes compromised, also in otherwise healthy individuals (Inbar et al., 2004). Research on the heat wave in France in 2003 showed that 80% of all deaths caused by heat stress were people older than 75 years (Grynszpan, 2003). Similar findings were made in the United States and Australia (Anderson et al., 2009; Vaneckova et al., 2010). Vandentorren et al. (2006) found that during the 2003 European heat wave, older adults were significantly more likely to die because of heat stress if their houses had poor thermal insulation or the bedroom was located on the top floor. They also found that living in an urban heat island significantly increased morbidity levels among older adults during this heat wave.

b.) Sensitivity

The second contributor to heat vulnerability is sensitivity. According to Verbeke et al. (2001), sensitivity in this context means that an individual is less able to regulate and adapt their body temperature. Wilhelmi & Hayden (2010) describe sensitivity as 'the extent to which a system or population can absorb impacts without suffering long-term harm'. Translating this to the individual level, it could be defined as the amount of heat exposure someone can endure before it creates long-term harm, which is dependent of the individual's ability to regulate his body temperature. As has been mentioned before, age and health conditions are determining factors when it comes to sensitivity to extreme heat (Åström et al., 2019; Inbar et al., 2004). Case studies have shown that older adults, obese individuals, people using certain medications, socially isolated individuals, poor, the mentally ill and those without air conditioning are disproportionally affected by elevated temperatures (Wilhelmi & Hayden, 2010). In older adults, combinations of the risk groups mentioned above occur frequently (Scharf et al., 2004). This makes older adults often highly sensitive to urban heat.

c.) Adaptive capacity

Finally, the adaptive capacity of individuals forms the final contributor towards heat vulnerability. According to Wilhelmi & Hayden (2010), this contributor consists out of household knowledge, attitudes & practices, household resources, social capital and community resources & risk reduction programs. Adaptive capacity is highly correlated to exposure and sensitivity. Namely, adapting to extreme heat means that an individual should avoid as much exposure as possible, especially when someone is sensitive to heat stress as well. This is more difficult if an individual is less mobile and lives in social isolation, which is often the case among older adults and reduces their adaptive capacity (Arnberger et al., 2017). Coping mechanisms can be seen as putting adaptive capacity into action and are thus shaped by household knowledge, attitudes & practices and household resources, including mobility. Studies have shown that individuals vulnerable to heat stress often don't perceive themselves as such (Wilhelmi & Hayden, 2010; Lane et al., 2014). This is a problem since this will reduce the adaptive capacity of an individual and might increase their vulnerability to heat. For example, those with a positive attitude towards heat might underestimate the heat and not take the measures to adapt.

Research from the 2003 heat wave in France showed that the lack of mobility was a significant contributor to morbidity and mortality risks among older adults (Vandertorren et al., 2006). They additionally found that small adaptations like dressing more lightly were protective factors, just like the use of air conditioning. Beyond the individual level, there is also a role for the local community of which the individual is part of. According to Smit & Wandel (2006), ''in the climate change field, adaptations can be considered as local or community-based adjustments to deal with changing conditions within the constraints of the broader economic–social–political arrangements''. For example, subsidizing air conditioning for older adults can be considered as such a community-based adjustment. According to Belmin et al. (2007), the most vulnerable older adults are those living in institutions, confined to bed or living alone. On the other hand, healthy older adults often report a high level of adaptive capacity because of their lack of the constraints of a working life, making it easier to change daily routines (Malmquist et al., 2022). This study also found that some older adults enjoy the heat and even worship the sun. This might indicate that older adults are unaware of the risks of heat and might need to adapt to the new reality of warmer summers because of climate change.

2.3 Urban Green Spaces

The Urban Heat Island-effect is caused because of human interferences in the natural environment (Kleerekooper et al., 2012, Oke, 1987). According to Heidt & Neef (2008), almost every city in the world is usually 1° to 4° Celsius warmer than its surrounding rural area. Urban Green Spaces have been proven to be very effective in combatting the UHI-effect (Anderegg et al., 2012; He et al., 2020; Teskey et al., 2015). According to Aram et al. (2019), UGS entail various shapes and scales and include small local parks, large urban parks, urban forests, urban gardens, green roofs, green facades and street trees. By evapotranspiration, providing shade and altering air circulation, UGS are not only cooler than the surrounding urban area but also provide cooling effects to this surrounding urban area (Oliveira et al., 2011). This phenomenon is called the 'urban green space cooling effect' (Aram et al., 2019). Besides that, UGS also provide nature conservation, biodiversity, cleaner air, opportunities for recreation and well-being, increased human health and higher property values (Heidt & Neef, 2008). For the scope of this research, the cooling effects and the health & well-being benefits of UGS will be further explained, and specifically how this influences older adults.

2.3.1 The cooling, health & well-being effects of Urban Green Spaces

a.) Cooling effects

According to a literature review study by Aram et al. (2019), the urban green space cooling effect occurs both in large, middle-sized and small parks. Nevertheless, the cooling effect density (CED) and cooling effect intensity (CEI) were dependent on several factors, namely park size and shape, type and amount of vegetation cover and the regional climate. To give an indication of this effect, Hamada & Ohta (2010) found that during summers, the Heiwa Park in Nagoya, Japan (147 ha size) had an up to 1.9° Celsius lower temperature than other areas. During nighttime, this effect was noticeable up to 300 meters outside the park and during daytime up to 500 meters. A similar study carried out in Lisbon by Oliveira et al. (2011) found similar results. They found that especially on hot and dry days, the difference between a small UGS and the surrounding urban area was large. Contributing factors to this effect were found to be many shaded areas in the UGS, strong evapotranspiration inside the UGS and an intense built-up area surrounding the UGS. It has also repeatedly been found that the cooling effect of UGS is correlated with the size of the UGS, but this is only valid up to a certain threshold size, after which increases in park size do not further reduce temperatures (Mikami & Sekita, 2009; Yu, 2018). Paradoxical findings are also commonplace in the field of UGS cooling effects. For example, a study by Monteiro et al. (2016) in a London park found that the cooling effect distance was strongly correlated to the tree canopy, while the cooling effect intensity was strongly correlated to the grass coverage. Controversial findings occur as well. Some studies found that the shape complexity of an UGS is positively correlated with its cooling effect, while others found that it is negatively correlated (Yu et al., 2020). Besides green spaces, blue spaces are also known to reduce the UHI-effect, but it is even less well understood than the cooling effect of green spaces (Yu et al., 2020). Research in the Netherlands by Jacobs et al. (2020) found that small water bodies commonly found in the Netherlands such as canals, ditches, ponds and *singels* hardly create a cooling effect. Simultaneously, Tan et al. (2021) found that in Nanning, China water bodies were per hectare more capable of creating a cooling effect than green spaces.

b.) Health & well-being effects

Green spaces in general have been linked to various physical and psychological health benefits through their acclaimed effect on physical activity (Lee & Maheswaran, 2011). Physical activity is linked to many physical health benefits, such as effects on cardio and cerebro-vascular disease, diabetes, colorectal cancer, depression and fall-related injuries. Additionally, physical activity also improves mental functioning, mental health and well-being and has long-lasting psychological benefits. A relationship with longevity has also been reported (Lee & Maheswaran, 2011). Urban Green Spaces provide an opportunity for 'green exercise', such as walking (Pretty et al., 2003). There is scientific consensus that 'the built environment can facilitate or constrain physical activity' (Lee & Maheswaran, 2011).

The seminal work by Takano et al. (2002) found that independently from other factors, the availability of green spaces in urban environments is associated with increased survival in elderly populations. There is also evidence that higher levels of greenness in the environment is related to lower stroke mortality (Hu et al., 2008). Lafortezza et al. (2009) add to this that UGS and the exposure to green elements in general can promote quicker recovery from surgery, create relief from stress, improves cognitive capacities such as direct attention and have a greater capacity to promote psychological restoration compared to built-up areas. They also add that residents in areas with high levels of UGS are more satisfied with their neighborhood. Multiple studies have also found that green spaces create a variety of psychological, emotional and mental health benefits (Lee & Maheswaran, 2011). A large epidemiological study in the Netherlands found a positive relationship between the quantity of urban green spaces and the perception of one's general health (Maas et al., 2006). Lafortezza et al. (2009) specifically looked into the role of UGS during periods of intensive heat in Italy and Great-Britain. They conclude that 'frequentation and use of green spaces could generate benefits and well-being on people and this could be explained by the capacity of green spaces to provide better thermal comfort during periods of intensive heat'.

c.) Older adults' motivation to visit UGS

Naturally, all health and well-being benefits mentioned before are valid for the elderly population as well. But some studies have investigated the specific benefits older adults can obtain by using UGS or living near them. According to Enssle & Kabisch (2020), UGS offer places of encounter in a city, which can counteract the social isolation of older adults. Social isolation is known to be a risk factor for fatal heat stress (Harlan et al., 2006). High levels of UGS are also related to older adults feeling less lonely

(Maas et al., 2009). Lee & Lee (2019) found that older adults experienced less stress and fewer depression symptoms in environments with higher levels of urban greenery. Older adults are also more likely to be physically active if the neighborhood provides green spaces (Mytton et al., 2012). Enssle & Kabisch (2020) argue that this is specifically the case when community-based programs are offered and when the UGS integrally provides opportunities for social interaction.

In a discrete choice experiment in Vienna, Arnberger et al. (2017) studied UGS preferences among older adults living in an UHI during hot days. They found that distance to an UGS was a significant predictor for older adults for their chances to visit an UGS, in line with previous research (Lee & Maheswaran, 2011; Lachowycz & Jones, 2013). Concurrently, Lachowycz & Jones (2013) further state that the attractiveness of the UGS functions as a moderator for distance to that UGS. The more attractive the UGS, the less important distance becomes. Other moderators include opportunity to use UGS (health status, adaptive capacity, availability of time and transport), personal drivers & motivation to use UGS (physical activity, dog walking, bird watching) and the ease of use of the UGS (access to appropriate clothing, safety). Access limitations can prevent older adults from visiting UGS, but an increase in mobility can largely compensate for this (Wen et al., 2020). Arnberger et al. (2017) further found that older adults prefer access routes to UGS with trees, while benches were not a significant factor. Another study did find benches to be important, both on access routes and in the UGS itself (Kemperman & Timmermans, 2006), but this study did not specifically investigate this dynamic during hot days. For the green space itself, Arnberger et al. (2017) found the following preferences among older adults: the presence of trees with a high canopy cover, water bodies, presence of friends, toilets, no traffic noise, not too many people, but also not too few people, and preferably not too many dogs.

2.3.2 Heat stress coping mechanisms and the role of UGS

Undesired environmental stressors such as heat can be mitigated by coping mechanisms, aiming to reduce heat stress (Arnberger et al., 2017). According to Kemen et al. (2021), coping mechanisms can be categorized in three groups: body-related strategies, home-protective strategies and activity-related strategies. Eventually, all these measures are aiming to reduce exposure and are dependent on the adaptive capacity of the individual.

Body-related and home-protective strategies

Little research has been done on the coping mechanisms deployed by older adults during heat periods. A study in Australia found that the use of air conditioning, adaptation of daily activities and changing dietary habits were the most common coping mechanisms among this group (Banwell et al., 2012). Kemen et al. (2021) performed a study in Cologne, Germany, interviewing 258 older adults over 65 years old regarding their coping mechanisms during heat waves. Figure 3 below shows their findings. Examples of body-related strategies include e.g. wearing less or thinner clothes, drinking more fluids and eating differently. They found that strategies of cooling the body with water were little used by the sample group. Examples of home-protective strategies include e.g. using thinner beddings, opening windows for ventilation and turning on a fan or air conditioning. The most striking result here was the very limited use of air conditioning inside the house, by only 3,9% of the sample group. Air conditioning inside the house is a very effective coping mechanism against heat and is associated with decreased mortality risk during heat waves (Bouchama et al., 2007). In many non-European countries, the use of air conditioning is the main or even the only coping mechanism against heat (Kemen et al., 2021). In Northwestern Europe however, use of air conditioning is rarer. Lane et al. (2013) found that in New York city, many people use fans as a coping mechanism against heat. Extensive research however has shown that fans have no protective effect during periods of extreme heat (Kilbourne, 1982). All in all, there is only so much a vulnerable older adult can do to prevent exposure to heat inside their own house. Sensitivity factors such as socio-economic status & health and exposure factors such as housing type & the presence of air conditioning are mostly fixed and have a large influence on the vulnerability to heat (Kemen et al., 2021). Individuals should then look outside the confines of their own home to reduce their exposure to heat.

Figure 3: Coping mechanisms used by a random group of adults over 65 years old in Cologne during heat waves

Coping Strategy	***n*** **(%)**
Body-related strategies	
Wear less or thinner clothes	256 (99.2)
Drink more fluids	206 (79.8)
Eat differently	195 (75.6)
Shower more frequently	183 (70.9)
Cooling arms with water	78 (30.2)
Using wet towel	60 (23.3)
Cooling feet with water	59 (19.4)
Home-protective strategies	
Open windows for ventilation	250 (96.9)
Use thinner bedding	237 (91.9)
Close blinds/shutters	221 (85.7)
Turn on fan	122 (47.3)
Air Conditioning	10 (3.9)
Activity-related strategies	
Less physical activity	207 (80.2)
Reschedule activities	198 (76.7)

Source: Kemen et al. (2021)

Activity-related strategies

Activity-related strategies can include rescheduling and reducing physical activities (Kemen et al., 2021). Over 75% of the respondents in this study stated that they reschedule activities or reduce physical exercise during hot days. Another activity-related strategy would be to actively seek colder places such as urban green spaces, blue spaces or indoor locations. Arnberger et al. (2017) were one of the first to study the coping strategies of older adults in an UHI in Europe (Vienna) during a heat wave. They found that during hot days 55% prefers to stay in their home, 31% prefers to go outdoors and 14% prefers to go to their second home.

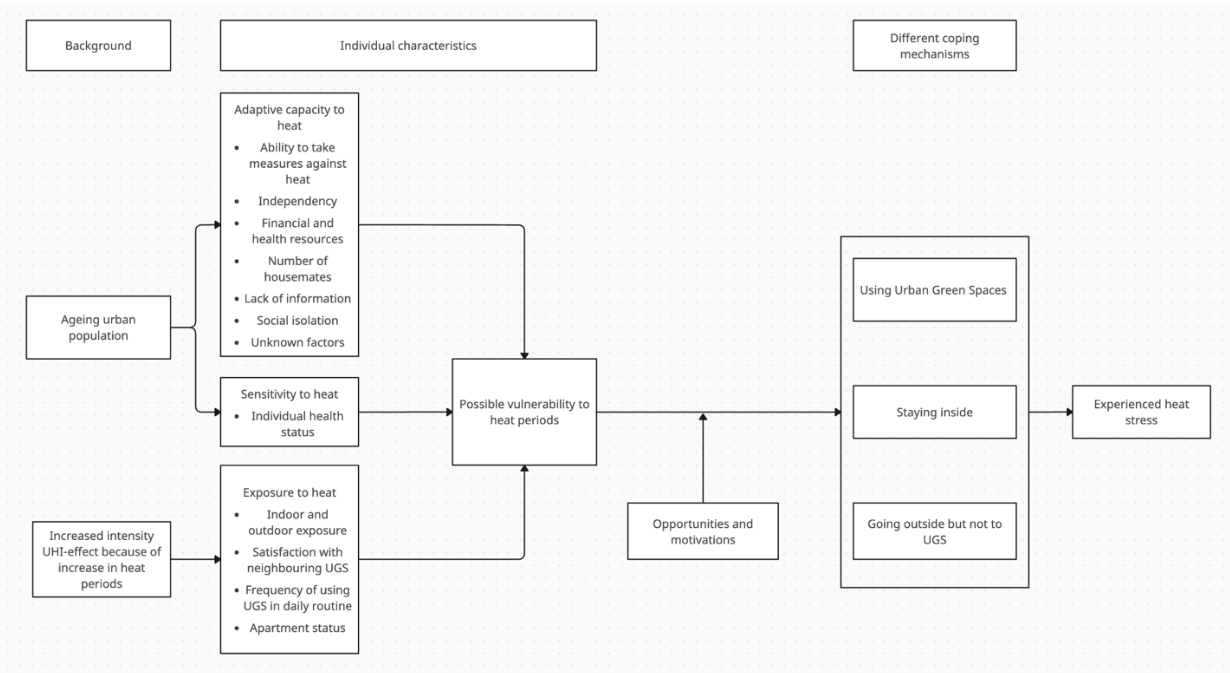
It is known that during heat waves apartments often become hotter than surrounding urban green spaces (Franck et al., 2013). Lafortezza et al. (2009) studied UGS use during hot days in Great-Britain and Italy, and found that the perception of thermal discomfort could be alleviated during heat periods by visiting urban green spaces. Arnberger et al. (2017) found in their sample that older adults who use staying home as a coping strategy reported a lower health status and were often single. They often responded they think that their own home is cooler than a nearby green space. Anyhow, 90% of all respondents would visit an UGS during hot days if it would be cooler than their own house. Yet, their poor health status reduces their adaptive capacity and thus their possibilities to access local urban green spaces or other places of refuge. Mees et al. (2015) and Wanka et al. (2014) found similar results showing that those staying at home live in less privileged apartments and report poorer health status. It is this group that is most vulnerable to heat stress in UHI's.

Arnberger et al. (2017) showed that within the group that went outdoors, 95% went to urban green spaces. It should be noted that for the biggest part, this group also visits UGS regularly outside of hot days. Cool indoor spaces, blue spaces and open-air baths with entrance fees were also frequently answered, but less than urban green spaces. Almost half of the sample group went to a private garden/courtyard, for example at friends or family. This indicates that urban green spaces play a vital role for this group as a coping mechanism against heat stress, in tandem with other coping strategies.

Certain factors were also found to be negatively influencing the probability to visit UGS during periods of heat as a coping mechanism, such as social isolation & a lack of financial - and health resources (Arnberger et al., 2017). Those coping primarily by staying inside the house often also live in less privileged apartments and report a poorer health status (Mees et al., 2015; Wanka et al., 2014). They further argue that people might be unaware of the fact that UGS are often cooler than their own apartment, which adds a lack of information as another factor for not visiting UGS.

Although these findings have been found multiple times in different countries, assuming them to be valid in the Netherlands as well should not be the automatic conclusion. Motivations for using and not using UGS differ over contexts and cultures and general conclusions are hard to make regarding this (Lachowycz & Jones, 2012). This study is not aiming to statistically prove certain factors to promote or prevent older adults to visit UGS during periods of heat. Rather, this study aims to create a deeper understanding of vulnerable older adults' reasons and motivations to visit or not to visit UGS during periods of heat.

Figure 4: Conceptual Framework



Source: Made by author

3. Methodology

3.1.1 Research methods

Older adults' decision to visit UGS during periods of heat is influenced by many possible factors. Different individuals experience different vulnerabilities to heat and personal characteristics make every individual unique in how they cope with periods of heat. Some people might spend time outside most days of the year, while others fare well staying inside. Qualitative research methods are most suitable to create a rich description of complex phenomena compared to quantitative methods (Sofaer, 1999). One such method is interviewing study participants. Interviews allow for personal and nuanced answers while the researcher has the option to ask deeper probe questions when necessary. In this way, participants can get the opportunity to explain why they show the behavior they show during periods of heat. Therefore, conducting interviews among older adults vulnerable to heat stress in Groningen creates the best opportunity to find out to what extent this group both experiences heat stress and subsequently takes measures to deal with that.

This research can be called explorative, and therefore semi-structured interviews will be held. Semi-structured interviews allow participants to provide answers as complex and diverse as they like, but simultaneously enable the researcher to stick to a general plan. The explorative nature of this study benefits from the option to ask specific probe questions based on participants' answers, which is best handled by semi-structured interviews. Most questions asked are open-ended and allow for a diverse set of possible answers. The goal is to first find out how someone lives their days in general, outside periods of heat. This includes finding out how UGS are used day-to-day. After that, the questions will be more focused on the experience of heat. This will also include questions on how they use UGS during periods of heat. Using this design, the different roles of UGS during periods without heat and periods with heat can be compared.

3.1.2 Data collection

Although this study is about older adults vulnerable to heat stress, it is not said that these older adults experience heat stress on a regular basis. 'Older adults vulnerable to heat stress' refers to the combination of sensitivity, adaptive capacity and exposure to heat, as mentioned in the theoretical framework. Multiple factors could be taken into consideration to assess if an individual could be considered vulnerable, but for practical reasons this study uses a few. Since the body's capacity to regulate heat declines with age, being over 70 years old is used as an indicator for being sensitive to heat stress. For adaptive capacity, this study uses the same approach as Arnberger et al. (2017), by stating that living alone and independently are indicators for a reduced adaptive capacity. Living alone increases the chance of social isolation which is associated with more risks during periods of heat and a lower probability to visit UGS during these periods. A reduced mobility is considered to lower someone's adaptive capacity as well. For this study however, it is important that the interviewee is at least capable of visiting UGS during hot periods. Therefore, this study does not include participants that are completely home bound. Finally, exposure to heat is determined by living location and housing conditions. This study considers urban environments in general to be Urban Heat Islands, as nearly any built environment area creates this effect (Ward et al., 2016). This study considers living in an apartment without a personal garden in an UHI to meet the requirements as to have a high exposure to heat. Despite all these requirements to be considered an 'older adult vulnerable to heat stress', it is not required that all participants consider themselves vulnerable to heat and experience heat stress due to variations in health status, age and attitudes.

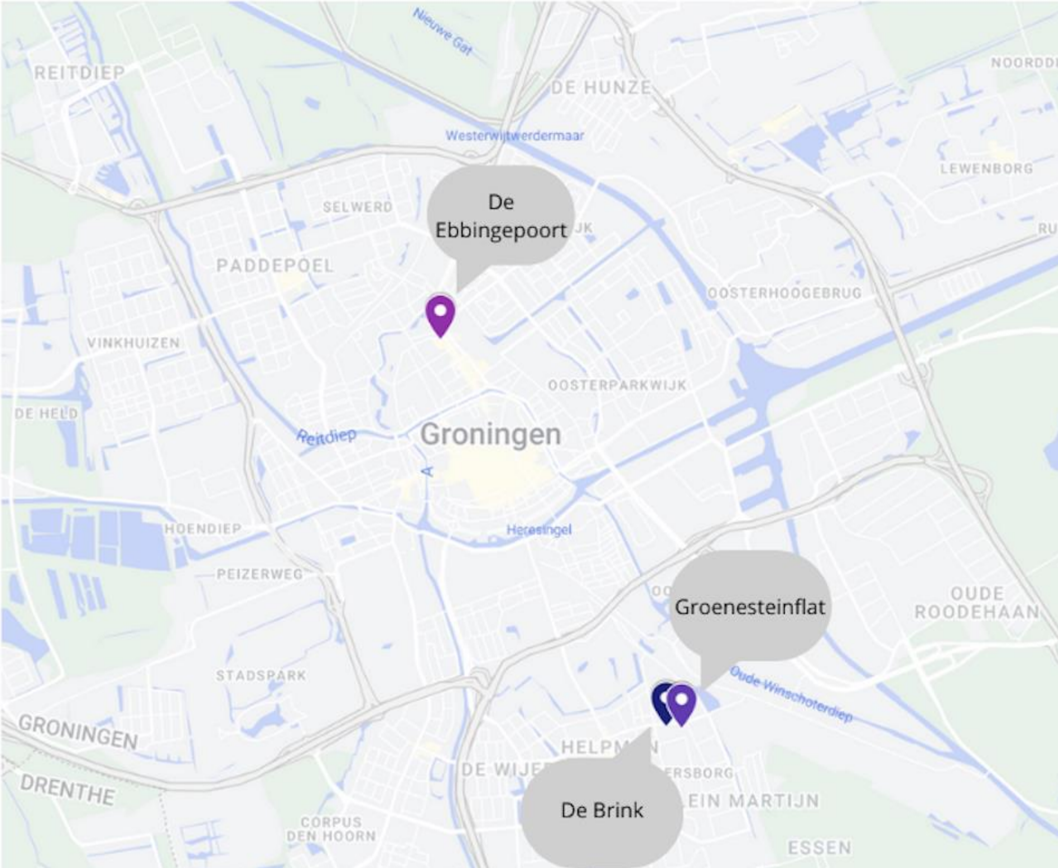
Participants were found using a combination of purposive sampling and snowball sampling, which are often used together (Parker et al., 2019). Purposive sampling is used because this research is specifically focused on older adults with the characteristics described above. Using the researcher's own network, two participants were contacted who are living in *De Brink* and the *Groenesteinflat* in Helpman, a neighborhood in the south of Groningen. Using snowball sampling, four other participants were selected via them. The final two participants were found after reaching out to *De Ebbingepoort*, in the neighborhood *Ebbingekwartier* in Groningen. The local manager found two residents with the specific characteristics necessary for this study. To increase the diversity of the sample, a central and peripheral location were chosen within the city of Groningen. The central location might experience more of the UHI-effect, which might affect the level of heat stress and associated coping behavior. *De Brink* is a residential complex owned by *Zinn,* and houses both people who need a lot of care and people who can live largely independently. The two participants in this study live in the independent part. The *Groenesteinflat* is a service flat intended for people above 55. People live here independently, but employees from the nearby *De Brink* can come by to execute health care tasks. Finally, *De Ebbingepoort* is a *woonzorgcentrum,* where people live largely independently. Healthcare services are available and most people make use of them, as was explained by the manager.

The interviews were held in Dutch at the participants' home location. This was deemed most comfortable for them and gave the researcher the opportunity to get familiarized with participants' daily living environment. This makes it especially easy to explain coping mechanisms within the house, as these can be pointed out by the participant. A table with all participants and relevant characteristics is shown below:

Table 1: Participant characteristics

Participant	**Age**	**Gender**	**Living location**	**Interview date**	**Self-assessed health score and health issues**	**Housing type**
1	90	Female	De Brink	30-04-2024	7, Parkinson's disease	New apartment, fifth and top floor facing the west
2	91	Female	De Brink	30-04-2024	8	New apartment, fifth and top floor, facing the west
3	77	Female	Groenesteinflat	03-05-2024	4, arthrosis, heart problems, one longue	Old apartment, eighth floor, facing the south and west
4	78	Male	Groenesteinflat	06-05-2024	6.5, balance disorder	Old apartment, ground floor, facing the south
5	79	Female	Groenesteinflat	06-05-2024	8	Old apartment, sixth floor, facing the east
6	75	Female	Groenesteinflat	07-05-2024	6, has had a cerebral infarction in 2017 and sits in a wheelchair	Old apartment, sixth floor, facing the south and west
7	69	Male	De Ebbingepoort	16-05-2024	7, diabetes and is a smoker	Old apartment, ground floor, facing the east
8	78	Male	De Ebbingepoort	16-05-2024	7, has had cancer and now has a stoma	Old apartment, ground floor, facing the north

Figure 5: Map of participants' residential locations



Source: made by author, using Google My Maps & Canva

3.1.3 Data analysis

The audio files of the interviews were transcribed using goodtape.io. The resulting transcriptions were not transcribed completely correct. Therefore, every transcript was listened to manually as well to improve the transcriptions. After this, the interviews were coded using Atlas.ti. The analysis of these transcripts was done using a thematic analysis. In a thematic analysis, the data is divided in themes relevant to the research (Braun et al., 2019). These themes are closely linked to the different codes. The coding was done based on the theoretical framework and can therefore be called deductive.

To identify heat stress, answers indicating adaptive capacity to heat, sensitivity to heat and exposure to heat were coded separately. Answers showing how participants behave during periods of heat were coded as 'coping mechanisms', or 'coping mechanisms using UGS.' These codes resulted in many quotes, which were crucial to answer the research questions. In total, this resulted in more than 400 quotes. In the appendix an overview is provided of all quotes and how frequently they have been used.

These quotes were analyzed by the researcher to find an answer to the research question. The quotes were translated from Dutch to English by the researcher, which could result in subtle interpretation differences. This might lead to a bias in the results, but this is nearly inevitable with this kind of research. However, the researcher has written down the results with integrity and respect to the participants' original answers.

3.1.3 Ethical considerations

Before the interview started, an informed consent form was signed by the participants, after reading them through and the researcher answering any unclarities after reading the form. The form explains that this research is in line with the General Data protection Regulation (GDPR). Then the interview was executed and recorded by the researcher. This study involves the use of personal information from older adults, and therefore, strict ethical standards have been upheld throughout the research process to ensure the privacy and dignity of the participants. To protect the identities of the participants, all personal data has been pseudonymized. Despite this measure, the living locations of the participants are presented in the thesis, which introduces a minimal risk that individuals may be recognized based on the descriptions provided.

The raw data collected during this study is strictly confidential and is accessible only to the researcher and the assessors involved in the evaluation of this thesis. This restricted access further ensures the protection of participant identities and the sensitive nature of the information shared. For the analysis, several online services were used to analyze the raw data. Goodtape.io was used for transcribing the audio files, and Atlas.ti was used for the coding. These services also operate in line with the GDPR (Good Tape, 2024; Atlas.ti, 2024).

As the researcher, I acknowledge my position as a white male who is younger than the participants. This demographic difference necessitated a careful approach to minimize potential biases and ensure that the participants' voices and experiences were represented as accurately and authentically as possible. In my analysis, I tried to remain true to the original answers provided by the participants, honoring their perspectives and contributions to this research.

4. Results

Chapter 4.1 first shows how participants' exposure -, sensitivity – and adaptive capacity to heat look like, without looking too much at their behavior during periods of heat. How heat vulnerability leads to heat stress and associated coping behavior is explained in chapter 4.2, including the role of UGS. At the end of this chapter, it will both be clear to what extent the participants of this study experience heat stress and how they use UGS during periods of heat to protect them against heat stress. Additionally, the use of other coping mechanisms besides UGS is analyzed.

4.1 Exposure -, sensitivity- and adaptive capacity to heat

Chapter 4.1 provided a brief overview of the heat vulnerability of the participants in this study. This section describes in more detail how exposure -, sensitivity – and adaptive capacity to heat are experienced among participants. As explained in the theoretical framework, vulnerability to heat stress consists out of three main components: adaptive capacity -, sensitivity – and exposure to heat. Adaptive capacity refers to the capacity of older adults to adapt to heat. This refers to the ability of employing coping mechanisms such as using sunshades, going outside and having options to go to during periods of heat. Core characteristics of adaptive capacity are mobility and the degree of social isolation. A lack of information about the potential dangers of heat is also part of adaptive capacity. Having a positive attitude towards periods of heat might make people underestimate the risks associated with heat. Therefore, attitudes to heat are also treated as a part of adaptive capacity in this section. Sensitivity to heat refers to the ability to regulate and adapt body temperatures. Older adults on average are less capable to regulate their temperatures than younger age groups. This can be exacerbated by health issues. Therefore, older adults are more often have a higher sensitivity to heat compared to other age groups. Finally, exposure to heat refers to the environment an individual lives in. Housing conditions, building density and the amount of UGS all add to this. If someone is exposed to heat in his daily routine, this might increase the risks of experiencing heat stress too.

4.1.1 Exposure to heat

Exposure to heat is one of the three components out of which the concept of 'heat vulnerability' exists, besides sensitivity and adaptive capacity. Exposure to heat refers to the environment an individual lives in, in a broad sense. The thermal comforts inside someone's house and at the places someone goes to during the day are part of the exposure to heat. Exposure to heat mainly refers to the heat participants must endure without having much of a choice. For example, actively sitting in the sun during periods of heat is more an example of someone's personal attitude towards heat than exposure. Heat that gets trapped and lingers inside someone's house is an example of such exposure to heat. This chapter provides an overview of how the participants in this study are faced with exposure to heat.

Some participants complained about a high exposure to heat inside their house. An example of this was given by participant 3, living in the *Groenesteinflat*:

"In here it gets incredibly hot. This is the eighth floor, and then you have all those windows. It just gets so hot in here. I do have sunshades for all windows and for the balcony which I roll out in the morning, but still, it is unbearable in here."

This apartment is facing the south and has many windows towards the south and the west, which makes it a sunny apartment for large parts of the day. Despite using sunshades, which are an example of adaptive capacity and will be discussed later, the temperatures still rise to levels that are called unbearable by the participant. The balcony itself is also facing the south-west, which makes it not a comfortable place to be during the day according to the participant. Participant 6 is living on the same side of the building and admits too that it gets very hot in her house during periods of heat and that she feels a strong need to go outside during these moments. Participants 4 and 5 also live at the *Groenesteinflat,* but their houses are catching less sunlight during the day. These participants explained that their apartment does not get very hot during periods of heat.

Participant 1, living in *De Brink*, experiences exposure to heat inside her house too:

"This is the top floor, five stories high, it's bloody hot, bloody hot. Most of the time more heat is coming in than getting out."

Participant 2 lives next to participant 1, but never experienced a summer there since she moved in in September. Thus far, she has not experienced a high exposure to heat in her apartment. The other participants of the study did not experience that their apartment was getting very hot during periods of heat. This might be because they adopted measures to prevent heat from coming in too much, which will be discussed later.

4.1.2 Sensitivity to heat

Similar exposure levels to heat can have different outcomes on the degree of experienced heat stress. Sensitivity to heat is an important factor moderating this relationship. Sensitivity to heat refers to the ability to regulate and adapt body temperatures. This ability is known to decrease with age, but additional health issues and syndromes can exacerbate this sensitivity further. Most of the participants explained to have health issues to a certain extent. Examples include Parkinson's disease, a balance disorder, cerebral infarction and (treated) cancer resulting in a stoma. Some participants admitted experiencing negative health effects because of heat, like participant 7:

"When it's hot, I experience more shortness of breath, but not extremely."

This is an example of a direct causal link between sensitivity to heat and immediate experienced heat stress. In this case, the participant is aware that the shortness of breath is caused by the heat. Participant 1, who suffers from Parkinson's disease, notices problems too:

"I'm just tired of it then, when it's so hot. Just because of the heat. I'm not active then."

These is a clear example too of how being exposed to heat can lead to issues during periods of heat. Such direct symptoms were not reported among the other participants. Whether underlying health conditions such as Parkinson's disease are responsible for the symptoms cannot be proven. However, such conditions in general increase the sensitivity to heat increasing the chances of experiencing heat stress. Also, for participants it might be difficult to pinpoint how their specific health status influences their degree of experienced heat stress. In any case, such conditions probably influence their adaptive capacity to heat. For example, someone who has had a cerebral infarction and therefore sits in a wheelchair might not immediately suffer more because she sits in a wheelchair, but it does limit her adaptive capacity to heat stress which might increase suffering from heat. This dynamic will be further discussed in the next part.

4.1.3 Adaptive capacity and attitudes to heat

Adaptive capacity to heat is the last contributor to the definition of heat vulnerability, besides exposure and sensitivity. It refers to the capacity of older adults to adapt to heat through employing coping mechanisms. Whether these coping mechanisms are applied will be discussed in the next section, but this section specifically looks at the 'toolbox' participants have to deal with periods of heat.

Before diving into the options participants have to adapt to heat, it is important to know what attitudes they have when it comes to heat in general. Although heat can be a risk for older adults both in terms of morbidity and mortality, some of them enjoy it and have a positive attitude about it. Participant 1 explains:

"*Well, I really enjoy sitting in the sun. It doesn't get too hot for me easily."*

This example shows something about the participant's attitude towards heat, but also about exposure. Apparently, heat is not only something to be avoided by this participant, but also to actively expose herself to. Nevertheless, the decision to sit in the sun is optional and therefore says more something about the adaptive capacity - than exposure to heat. Later in the interview though, she admits that she also gets tired from the heat sometimes and has little energy. Participant 7, who likes the heat too, says:

"As soon as the sun begins, at nine in the morning I am sitting outside in front of my house already. When it is very hot in the summer as well. Then I take a glass of soda with ice cubes. […] I am a real 'buitenmens'."

But just like participant 1, this participant also admits experiencing negative effects of the heat. When it gets hot, he states to experience more shortness of breath, but not extremely.

Besides participants 1 and 7, participant 5 stated to like the heat too:

"*I am never bothered by heat, to be honest. I close the sunshades and then the heat is not coming in too much. […] I can handle the heat well too." […] To be honest, I despise winter."*

While the participants in this study were selected because of their implied vulnerability to heat, at least three of them explain to like the heat. Only participant 3 was clear in saying that she dislikes heat. When asked how she experiences hot summer days, she explains:

"It's heavy, very heavy. I can't even change my daily schedule, because I can't do anything at all. It is just way too hot. I have some kind of air conditioner next to me and then I stay inside, doing very little."

The other participants were more neutral about the heat, or only liking it until a certain threshold. Participant 2 explains that she doesn't like it if it becomes 30º Celsius, 25º Celsius is enough for her. Participant 8 explains too that he neither likes, nor dislikes hot days:

"I try to remain calm during hot days, that I'm not sweating all the time. But it's not that I become anxious from the heat. If there would be an activity like playing shuffleboard in the afternoon, I would still play shuffleboard."

These answers show that while not every participant enjoys hot days and perceives hot positively, there are no participants excessively worried about heat during hot days or in advance. None of the participants thought about heat as being dangerous. A feeling of resignation is recurringly prevalent, admitting that there's nothing that can be done about the heat rather than coping with it as well as possible. Participant 7 thinks that experiencing health stress also is a matter of mindset:

"I'm not really bothered by it. I always say, some people think 'Oh it's so hot'. But if you start thinking it is hot, then you will get hot."

This shows that older adults vulnerable to heat stress also use mental perceptions to deal with the heat. Deliberately choosing not to worry about it might increase their adaptive capacity in this way. On the other end, both participants 1 and 7 admit liking the heat in general, but simultaneously experience heat stress symptoms by feeling tired and having difficulty breathing. Underestimating heat can therefore also reduce the adaptive capacity of older adults.

Perceptions of heat can also change over time. Participant 4 explains that in his youth, he liked periods of heat, but not anymore:

"If there really is a heat wave, say 35° Celsius, I consider that a negative thing. But when I was younger, I found that very positive."

This shows that perceptions of heat can change over time within individuals. Something that was viewed positively a while ago can now be viewed very negatively.

Besides attitudes to heat, factors such as mobility, social isolation and financial resources also shape the degree of adaptive capacity. Mobility and social isolation among participants are already described in chapter 4.1 and will not be further presented here, except for the following example. Namely, how a lack of mobility because of health issues can be like is explained by participant 3. She explains that because of her health issues, such as arthrosis, a heart condition, having only one functioning longue and having an artificial hip and knee, she can do less and less things over time:

"I do whatever I can do, but every now and then something falls away and you must take a step back. […] I am happy if I have a good day, that I can walk to the Poeisz and back with my walker, but I can't do more than that."

Independency is another characteristic of adaptive capacity. Participant 3, troubled by many health issues, explains that this helps her in dealing with her situation:

"In fact, I don't have any real obligations anymore. If I come home and have backpain again, I take a painkiller and lay down on the bed for half an hour, and then I can go on. I can manage it totally."

Not having a schedule full of obligations allows for more rest when necessary. This also applies to periods of heat, where she can take things more easily and just stay inside if she wants to. Older adults often have fewer obligations than younger generations, since they are often not actively working any longer. This has a positive influence on pensioned older adults' adaptive capacity. A combination of a strong independency and financial resources was shown by participant 5. She has her own garden shed at *Piccardthof,* a complex where people have individual lots with sheds and gardens. Participant 5 explains:

"I think I am an exception, but I have my own vegetable garden with a garden shed. I have decided to keep that, because it is very nice. […] I like the freedom and the environment, it's so green. I always have my books with me."

Having the option to go to such a place during periods of heat indicates a high level of adaptive capacity. The wide use of e-bikes and mobility scooters among the participants can also be considered financial resources that have a positive impact on their adaptive capacity. Another resource often mentioned are sunshades. Except for participant 8, all participants have sunshades at their disposal. Finally, as shown in chapter 4.1, social isolation did not seem to play a role in reducing participants' adaptive capacity. All participants have regular social activities and no participant mentioned loneliness. Nevertheless, loneliness is not always visible from outside and might be a difficult topic to talk about.

Participant 7 mentions that he visits the city center regularly with his *mantelzorger,* a kind of informal caregiver. It is known that urban areas can get very hot during periods of heat, so it will be interesting to see if these participants can continue these habits during periods of heat. This will be discussed in the section on coping mechanisms. Participants 1, 2 and 6 specifically told that they never come to the city center because it is too busy.

Some participants explained to visit UGS regularly. It might be that visiting UGS outside periods of heat makes it easier to visit them during periods of heat as well, but this will be looked at in the section about coping behavior. Participant 8 is one of the participants visiting UGS regularly and visits the *Noorderplantsoen* almost daily. He explains:

"The main reason I go there is for the nature. I sit on the benches, the blackbirds and the sparrows and all that kind of stuff is flying around your head. I really hope I am still able to walk for a very long time."

Participant 7 also visits the *Noorderplantsoen* regularly, but for different reasons:

"I regularly go to the Noorderplantsoen. Then I go to the large playing field with my mobility scooter, where they are barbecuing. Then I will go stand next to them, and then I often eat with them! It's not that I'm coming there for the food, I come to enjoy being with others."

Besides these examples, participant 4 also mentions that he goes cycling on his e-bike in the direction of *Haren*, if the weather is not cold and wet. Technically he is not using UGS, but he is actively going towards a natural environment. These examples might mean that such spaces are also used during periods of heat, which will be looked at in the next chapter. It must be said that participants 1 and 2 have told to never visit (public) UGS.

4.2 Coping behavior and the use of UGS during periods of heat

Every decision an individual makes is a tradeoff. Choosing to do something means not choosing to do something else. The costs of these unchosen options are called opportunity costs. When thinking about the coping mechanisms of older adults vulnerable to heat stress, it should be acknowledged that leaving the house to do something can be a costly endeavor which costs need to be worth it. Coping mechanisms refer to all actions participants undertake that might help them to deal with periods of heat. This section is dedicated to the coping mechanisms participants employ during periods of heat, as was found during the interviews.

Some coping mechanisms need little effort to be employed. An example is the use of sunshades. Nearly all participants came up with this coping mechanism. Participant 7 explains:

"I like heat, but specifically here behind my house and under the sunshade. I am not going out during the heat; you need to adapt a bit."

All participants have sunshades installed in front of their windows and use them during hot days. The exception is participant 8, who has no sunlight at his house during the whole day. Sunshades are an easy and effective tool to prevent sun and subsequently heat from entering someone's house, which appears to be widely acknowledged by the participants. Some participants explained that they think sunshades are enough to keep the heat out, such as participant 4, 5 and 7. Others found them to be insufficiently effective in doing so, like participant 3 and 6. This is also dependent on the orientation towards the sun, since some houses receive more sunlight during the day than other.

Participants 1, 2, 5 and 7 use sunshades but simultaneously open the windows to let in fresh air during hot days, while participants 3, 4, 6 and 8 mentioned that they close the windows to keep the heat out. When asked if he can keep temperatures low in his apartment, participant 8 explains:

"Yes, I just keep the windows shut, I close the curtains. If you want to keep it cool, you need to close everything."

Another coping mechanism mentioned multiple times is the use of ventilators. Participants 1, 2, 3, 4, 6 and 7 use them to cool down and often have separate ones for multiple rooms, like the living room and the bedroom. Participant 3 explains:

"It's heavy, very heavy. I can't even change my daily schedule, because I can't do anything at all. It is just way too hot. I have some kind of ventilator and air-conditioning next to me and then I stay inside, doing very little."

Some participants will sit next to the ventilator as well, but participant 7 for example just lets them blow in his living room during the day and sits outside himself. Another way to adapt to heat mentioned multiple times by the participants is trying to do as little as possible and stay inside. When asked how hot days influence his daily behavior, participant 8 responses:

"Just not doing too much, staying calm. Then I just stay inside, they won't see me outside then."

Similar answers were provided by most other participants. They tend to stay inside during the hottest moments of the day, combined with closing the sunshades. This was the main strategy for participants 2, 3, 4, and 8. The participants often do get out of the house during these days for certain obligations, like shopping for groceries, but all of them try to do this in the morning or in the evening. Rescheduling activities outside the hottest moments of the day is also an example of a coping mechanism.

Participants 1, 5, 6 and 7 do get out of the house during the hottest moment of the day, and they all visit UGS, but not all in similar ways. Participant 5 has her own private garden at *Piccardhof,* as explained before. On visiting that during hot days she says:

"I go there by bike when it's hot and go sit under a tree, and then it's done. […] I also like sunbathing in such a lazy chair. I always make sure I have something to eat and to drink with me. […] I partially go there because I know there are trees, we have a big plane tree over there where you can sit underneath in the shadow."

She really enjoys this private UGS during periods of heat. When asked if she would also sit and read a book in a public park, she responses:

"It could be, we also have a communal terrace here. I could possible sit there too. But I have never done that, because I go to Piccardthof then. But if I wouldn't have that, I might go sit here as well. Or at the park here nearby (Groenesteinpark), I would look for a tree where I could sit underneath, and that would be fine too."

This indicates that this participant prefers a private UGS over a public one. Participant 1 regularly leaves her house too during hot days and goes to a private UGS as well:

"Sometimes when it's very hot, I walk to my daughter's house. I have a key. Then I will sit in her garden under the trees, where it is very cool."

Next to that, participant 1 also sometimes sits at the communal terrace of the apartment building, in the shadow under a parasol or sometimes in the sun if she feels like it. She was also asked if she would use any nearby public parks, which are present, during periods of heat. She negatively answered this question and refers to the *Groenesteinpark* as a 'dingy and unsafe' park. She specifically refers to the smelly water and refers to stories of men coming out of the bushes showing their bare ass. She further mentions to never visit the other nearby large park, the *Sterrebos.*

Participant 7 on the other hand always sits in the interior garden of the apartment complex when it's hot, as quoted in the section on the perception of heat. He has the option of sitting in a private communal garden with lots of flowers and a small pond, where he enjoys sitting during hot days. He also likes sitting there when it is not very hot, since he calls himself an '*outdoor person'.* In the previous section it was mentioned how he visits the *Noorderplantsoen* to enjoy the company of others, but when asked if he also does this during hot days he replies:

“No, because of how many people are there then. If many people come together, they also emit warmth. People are like ants, they tend to seek each other out, and then you get so much warmth. I'm used to hustle and bustle, but that gets to be too much for me.”

Therefore, instead of going to the *Noorderplantsoen* when it is hot, he sits outside of his house inside the private communal garden of the apartment complex. This means that this person does use public UGS during a regular, non-hot day, but does not do so when it is hot. He refers to UGS as being warm because of its crowdedness during hot days. He also visits the city center regularly during periods of heat but stops doing this during hot days as well. He specifically mentions how areas with a lot of buildings tend to retain heat, indicating that he is aware of the UHI-effect. The only participant who does use public UGS during the hottest parts of the day is participant 6. She explains that she likes to drive through the *Groenesteinpark* with her mobility scooter close to her house to enjoy the shadow of the trees for a short ride, but she doesn’t stand still there. She also does this during non-hot days, because she likes to make a ride in general, not just to avoid the heat.

Participant 7 mentions that he thinks public parks are warm during hot days. This perception of UGS is also mentioned by participant 2. When discussing visiting parks during hot days, she says:

“I think with 30, 40° Celsius, you would not go walk here in the park, I don’t think you would do that. A park is always much warmer, because the heat lingers there. You wouldn’t go to a park; you wouldn’t go walk on the streets in general.”

Two different participants refer to UGS as warm places during periods of heat, and participant 2 even states that warmth accumulates in parks. Although that is most probably untrue, it indicates that UGS are not unanimously associated with coolness in the study group. Participant 3 too does not use UGS to cool down during periods of heat and admits that it also never came up to her that it might be cooler in such places. When hearing about it during the interview, she thinks it might be a good idea for her to go to an UGS during heat. This shows that the cooling effect of UGS is not common knowledge among members of the study group.

Participant 3 earlier mentioned she is not able to do a lot when it is very hot and her main strategy is to sit next to a ventilator and sit still. Nonetheless, she does admit liking to take a ride with her sister during both hot days and non-hot days:

“During summer when the weather is good, I go out on my e-bike with my sister in her mobility scooter. She suffers a lot from rheumatism. Then we leave around 11 am and we drive through all kinds of places

all day. Then we take a seat somewhere and enjoy the good weather and being away from home. [...] We drink a cup of coffee or eat an ice cream in Zuidlaren for example."

Participant 3 has quite a few health issues, just as her sister as she explains. Nonetheless, they go outside and can enjoy hot days. She refers going to *Zuidlaren*, which is a route surrounded by greenery from Groningen. This shows that she is using green spaces during hot days, although they are not *urban* green spaces. What strikes here is the social aspect of going outside during periods of heat. The participant only makes this kind of rides with her sister and further admits to never visit UGS on her own. The social aspect of visiting UGS is also mentioned by participant 2, who says she likes going to the *Hoornse Plas,* but *"that is not the kind of thing you do on your own".* However, it there would be a swimming pool inside *De Brink,* she would go swim there. Participant 5 admits too she would like to go to an open-air bath more often, but just never gets too it.

Participants 4 and 8 state that they do use UGS during periods of heat, but only in the evening when it is cooler. During other days of the year, they do use UGS during the day and not necessarily only in the evening. Both participants use UGS mainly to enjoy nature and be physically active. Apparently though, these benefits do not weigh up against the burden of defying the heat while doing these activities. Participant 4 chooses to cycle in the direction of *Haren* since he enjoys the green environment during his route. He explains that if he takes his e-bike in the evening, he chooses a shorter route than he would usually do. This shows how hot days can force people to reduce their physical activity, even when it important for them to stay physically active.

5. Discussion, conclusion and recommendations

5.1 Discussing vulnerability and attitudes to heat

The core of this study evolves around finding out how older adults vulnerable to heat stress in Groningen deal with periods of heat. Specifically, the combination of a high exposure to heat, a high sensitivity to heat and a low adaptive capacity to heat increases the vulnerability. The study participants show various degrees of heat vulnerability, but only one participant reported disliking the heat. Other participants said to like the heat or are neutral about it. This shows that vulnerability to heat does not automatically lead to the experience of heat stress too. Similar results were found by Malmquist et al. (2022), who found that some older adults, labeled vulnerable to heat according to the literature, in fact stated to enjoy periods of heat.

Even experiencing symptoms of heat stress did not make participants to dislike periods of heat in general. Two participants admitted experiencing symptoms during heat like difficulty breathing and feeling tired, which are symptoms indicating heat stress according to Kalkstein & Greene (1997). Those indicating to suffer from health issues like diabetes, Parkinson's disease and lung diseases were the only ones to mention negative health effects during periods of heat, in line with the findings of Bouchama et al. (2007) & Kenny et al. (2010). They also refer to the worsening of pre-existing conditions as signs of heat stress, which was also mentioned by some participants. These can be qualified as mild to moderate symptoms of heat stress.

The healthier participants do relatively well during periods of heat. Anxiety, despair and worry because of heat periods were not mentioned by any of the participants, although other research has found that these feelings are commonplace among older adults vulnerable to heat stress (Hansen et al., 2011). It must be said that the adaptive capacity to heat was high among most participants even though they all live on their own, which in general is associated with a reduced adaptive capacity (Belmin et al., 2007). Though, it was very clear how sensitivity to heat influences the adaptive capacity to heat. Mobility is an important factor of adaptive capacity, and mobility is largely dictated by health status. Health status is an example of sensitivity to heat. Those with health problems showed to be less mobile too, in general. This provides fewer options to leave someone's own house, which makes them also more vulnerable to the level of indoor exposure. Nevertheless, mobility solutions like mobility scooters, e-bikes and walkers make it possible for all participants to go outside during periods of heat if they need to. Since these participants do not report high levels of heat stress, it appears that despite their reduced mobility they are still capable enough to go outside if necessary. These transportation methods are not cheap and indicate a high level of financial resources, associated with a higher degree of adaptive capacity (Arnberger et al., 2017). Next to being less mobile, Arnberger et al. (2017) also mention social isolation as a risk factor for a decreased adaptive capacity. Yet none of the participants called themselves lonely and when they described their daily activities during hot days, doing something with other people was mentioned frequently. However, this doesn't mean social isolation is not present in the study group, since loneliness can be hard to talk about.

These findings indicate that possibly the attitudes towards - and perceptions of heat are not solely the result of how much discomfort is experienced. People can still enjoy hot weather, even if they experience negative physical health effects. In the Dutch climate, where many months of the year it is relatively cold, it might be tempting to soak up the heat whenever the sun is shining. This was also found in Sweden among older adults vulnerable to heat by Malmquist et al. (2022). This behavior does not need to be problematic per se, but because of climate change maximum temperatures during summer are rising. If older adults have difficulties realizing this, it might hurt their adaptive capacity. Then someone can be in the position to be able to take measures against heat, but if he doesn't realize he should do that, his capacity to adapt to heat is reduced.

5.2 Discussing how adaptive capacity leads to coping behavior

Coping behavior refers to all behavior participants display in reaction to the prevalence of heat. Given the options someone has at his disposal (adaptive capacity), what choices does a participant make during periods of heat? Some of this behavior might only specifically occur during periods of heat, but it can also be that someone's behavior during non-hot days is continued during hot days. This can then also be coping behavior, since changing nothing at all might be the best option to deal with heat. Similarly, the fact that someone expresses not to suffer from heat stress does not mean this this person is not employing coping behavior. It could very well be that someone's behavior during periods of heat unconsciously helps them to deal with this heat. This section will especially focus on the choice of using UGS as a form of coping behavior.

To start with, all participants that had the option to use sunshades, use them during periods of heat. Outdoor sunshades are a great way to reduce the indoor exposure to heat, as they block the sun before it comes through the glass and warms the house. Once sunshades are installed, all it takes is pressing a button or using a lever to lower the sunshades. It is therefore a low-effort investment to use them during periods of heat, with possibly a large effect. Nevertheless, some participants find sunshades to work insufficiently to keep their house cool. Ventilators are also used among a large group of participants. Their effectiveness in cooling a person down is not convincing, but participants did admit liking them. Again, applying this method takes little effort and once someone has invested in buying a ventilator, it is very easy to use them as well. Some participants use these methods combined with opening the windows during the whole day. Although it might be appealing to let in fresh air, it most probably causes the indoor temperature to rise. Using such counterproductive strategies might indicate a lack of information of how to manage thermal comfort inside one's house. This could be due to a lack of public education about how to manage heat, which is a risk factor to heat vulnerability (Wilhelmi & Hayden, 2010).

Various participants using both sunshades and ventilators still tell that their house is getting very warm during periods of heat. Using these coping mechanisms could be expected considering the study by Kemen et al. (2021). In that study, carried out in Germany, 86% of the participants use sunshades and 47% uses ventilators. Just 4% of the participants in that study use air-conditioning. In countries with a warmer climate such as Italy and Spain, air-conditioning is used widely. It is the single most effective coping mechanism to keep indoor temperatures comfortable and prevent heat mortality (Bouchama et al., 2007). None of the participants in this study have air-conditioning installed in their house. Apparently, until this day the building owners do not see the necessity the include their apartments with air-conditioning. For older buildings like *De Ebbingepoort* and the *Groenesteinflat* this is understandable, since most houses in the Netherlands were not equipped with air-conditioning during the 20st century. But *De Brink* is just a few years old and specifically designed for older adults. Apparently, the associated costs were not deemed worth it to install air-conditioning, despite participants mentioning discomfort from the heat inside their apartments.

The use of sunshades and ventilators does indicate that there is the need for cooling among participants in this study, but it often fails to cool sufficiently. So, temperatures are on the rise because of climate change and older adults experience high heat exposure inside their house despite using coping mechanisms. It might be time to consider installing air-conditioning in more houses than is currently done if the society wants to protect the people most vulnerable to heat stress.

Having addresses the indoor measures, the focus now shifts to examining how individuals schedule their days during periods of elevated heat. To put it briefly, in general participants do less things when it is hot. Less visits to UGS, less long bike rides, less walks and less visits to the city. These activities are often replaced by staying inside. They also tend to stay closer to home compared to non-hot days when they do leave the house, although most participants stay close to their home during non-hot days too. This shows that although most participants do have the capacity to go out during periods of heat to seek better thermal comfort, they most often choose to stay inside their house. And they might do well in choosing to do so, as most participants do not experience large amounts of heat stress.

To understand why this is the case, it is helpful to first look at the participants who *mainly* use UGS during periods of heat. These are participants 5 and 7, respectively going to their garden shed and their communal interior garden. Having a garden shed with a secluded, private garden attached to it at the edge of Groningen can be considered a privilege. To get there, the participant needs to make a 20-minute bike ride which costs energy, but she is in good health and this is not an issue for her. The benefits to her are obvious: being able to read and sit down in a lazy chair with no one bothering her, the option to choose between sitting in the shadow or in the sun and to do some gardening. She can do what she likes to do most. She also does this outside hot days, so this behavior can be considered a routine. It is known that routines involving visiting UGS can reduce the vulnerability to heat, since this behavior is often continued during hot days (Lafortezza et al., 2009; Wanka et al., 2014).

Participant 7 also mainly uses UGS during periods of heat, and again this is a private place. This participant's health status is worse than for participant 5, but this participant needs to do less effort to get to the UGS. Namely, the interior garden of the *Ebbingepoort* is right outside his doorstep. He describes himself as a *buitenmens*, indicating that he likes to be outside in general. He regularly visits the nearby *Noorderplantsoen,* mainly to socialize with strangers, indicating the role UGS can have in Groningen to make older adults feel less lonely (Maas et al., 2009). Nevertheless, he stops doing this when it is too hot. His second-best alternative is the interior garden of the building. Again, the costs of this behavior are low, and the benefits are high. Namely, he can be outside where he likes to be, without having the costs of travelling to a park or other public UGS during a period of heat. It is noteworthy that this person does not consider the *Noorderplantsoen* as a refuge from heat. If that would be the case, the costs of transporting oneself to the UGS might be worth it. But the *Noorderplantsoen* is seen as warm and crowded during periods of heat. This is contradicting the findings by Lafortezza et al. (2009) & Arnberger et al. (2017), who found that in Great-Britain, Italy and Austria people visit UGS to experience better thermal comfort.

The other participants cope with heat stress *mainly* by staying inside. In a similar study by Arnberger et al. (2017), most respondents use this as their main strategy as well. In the current study, some do visit UGS during such periods, but sparsely or only around the edges of the day. The same applies to visiting other types of green spaces, such as cycling towards *Haren* as regularly done by participant 4. These participants already do this during non-hot days too. The only participant who introduces visiting UGS as new behavior during periods of heat is participant 1. But again, she has the option to visit a private UGS, namely her daughter's garden. This is a 15-minute walk, comparable to walks she usually makes during non-hot days. She knows what she gets there: a place to sit in the shadow without anyone bothering her, comparable to participant 5. This could again be expected looking at the study by Arnberger et al. (2017), in which nearly half of the respondents use a private garden or courtyard during periods of heat.

Those not visiting public UGS during periods of heat do so because they don't like public UGS, or they think it is too warm there. Public UGS can be cooler than people's houses (Arnberger et al., 2017), but many participants think this is not true or are unaware of this. In that case, it is not strange that participants stop visiting UGS during periods of heat or reschedule this to the evening. Namely, participants indicate to reschedule most of their activities to either the morning or the evening, like doing groceries or taking a bike ride. This allows them to rest during the hottest parts of the day, inside their house. Participants mention that their health issues without heat already require them to be thoughtful in what they do, like participant 3 stating that she only goes to the supermarket on 'good days'. Visiting public UGS appears to be such an activity that *costs* energy, instead of *providing* energy. For some participants, like participant 3 and 6, these costs are sometimes worth it. Participant 3 sometimes makes a bike ride with her sister to enjoy being outside, and participant 6 likes to make a ride on her mobility scooter to the nearby *Groenesteinpark* as well. But these activities are not done *because of* the heat, but moreover *despite* the heat.

It seems that in terms of seeking better thermal comfort, no place can provide a more comfortable environment than people's own home, or places very close to it like a communal terrace or garden. Other coping strategies frequently found by Arnberger et al. (2017) like going towards cool indoor spaces, going to blue spaces or open-air baths were not found among participants of this study. Social factors might play a role, as participants mentioned multiple times that going to a blue space or to the open-air bath is not something they would do on their own. Visiting indoor spaces such as churches, shops or libraries to cool down was never mentioned by the participants and appear not to play a role in providing thermal comfort during periods of heat. It might be that in the Netherlands, there is little cultural history of seeking shelter against heat stress. Therefore, going towards cool indoor spaces is not in the behavioral 'toolbox' of older adults during periods of heat, just like visiting UGS during periods of heat.

It could also be the case that doing such things is easier with other people. If that is the case, social isolation might harm the adaptive capacity of older adults, as described by Arnberger et al. (2017). What also could play a role is that the UGS itself are not attractive enough. The attractiveness of UGS is an important reason to visit them (Lachowycz & Jones, 2013), and older adults are also more willing to bridge longer distances to an UGS if it is attractive enough (Arnberger et al., 2017). If UGS provide more features that are valued by older adults, they might more easily visit such places and thus also experience the cooling effect of UGS. This study shows that older adults vulnerable to heat seem to seek features like privacy, a feeling of safety and with the ability to sit in the shadow.

Finally, communities might need to adapt to the new reality of warmer summers before implementing such measures. In Groningen, the municipality organizes a pilot during the summer of 2024 by opening cool rooms for citizens in two neighborhoods where the UHI-effect is high (Gemeente Groningen, 2024). It might be that such experiments familiarize vulnerable citizens with strategies to cool down and therefore become better in adapting to periods of heat.

5.3 Conclusions

This study aimed to understand what the protective role of Urban Green Spaces is for older adults vulnerable to heat stress during periods of heat. It did so by first exploring the level of heat stress experienced during heat periods and secondly finding out what coping mechanisms this group employs during such periods.

It was found that heat stress was experienced to a certain extent, but not to the degree of suffering. Sensitivity to heat and exposure to heat were found to have a strong relation to the adaptive capacity to heat. In this study, most older adults were well capable of adapting to the heat, but this appeared to be related to the degree of exposure and the degree of sensitivity to heat. The participants in general have a positive attitude towards heat, and periods of heat are not feared on advance.

Sunshades and ventilators are used widely as a coping mechanism, although often combined with behavior that is likely to increase indoor temperatures such as opening the windows during the day. This might indicate a lack of knowledge on how to keep a home cool during periods of heat. Urban Green Spaces were used by some older adults during periods of heat, but often this was not specifically used as an activity to protect themselves against heat. Moreover, those visiting UGS outside periods of heat tend to reschedule doing this during periods of heat, because they don’t like to go out of their house on the hottest parts of the day. This shows that public UGS are not considered as cool places to stay in these moments. Staying inside was mentioned most as the main coping mechanism against heat, followed by visiting a secluded UGS. These spaces, like interior gardens and private garden sheds, were used as a place to reside during the hottest moments of the day among participants with access to it, contrary to public UGS. Apparently, private green spaces can provide benefits that public green spaces cannot provide. Such benefits appear to be privacy, a place to sit in the shadow and safety.

5.4 Strengths and weaknesses

This research has a qualitative nature to create a deeper understanding of the relationship between heat stress, visiting UGS and employing other coping mechanisms. A total of eight participants have been interviewed. This group was diverse in age, health status and background, especially between the different residential locations, which resulted in different perspectives that added to the quality of this study. By taking semi-structured interviews, participants had the opportunity to explain their feelings during periods of heat and what kind of coping mechanisms they use during such periods. This worked well and participants were open and clear in their answers.

However, limitations can be mentioned as well. Not all participants visit UGS regularly outside periods of heat or during periods of heat. This limitation could have been avoided by recruiting participants inside UGS. That would have resulted in a study group biased to visiting UGS, which excludes older adults who never visit UGS. Since this study was also interested in this group, it was decided not to recruit participants within UGS. Interviewing older adults who all visit UGS on a regular basis might result in more insight into what it is that they value or miss in UGS during periods of heat and could be topic of study in future research.

5.5 Contributions of this study to the academic field

In the Netherlands, research on UGS preferences among older adults is scarce, just like research on heat stress among this group in general. This study has shed a light on both. The prevalence of heat stress is increasingly relevant in the Netherlands due to climate change and demographic changes in society. Increasing numbers of people are faced with morbidity and mortality risks during periods of heat. Understanding how this works and what makes people to experience heat stress, what this study has tried to do, is crucial for further research on heat stress in the Netherlands and other comparable countries. Because of their capacity to increase thermal comfort, UGS can be an integral part of the strategy cities can employ to make themselves more heat-resilient. This study has found reasons to visit and reasons not to visit UGS, which contributes to the academic field of UGS research within the Netherlands.

5.6 Recommendations for future research

Both research on heat stress and UGS can benefit from quantitative research methods too. The Urban Heat Island-effect can be measured from satellites and ground-observations, but it might also be interesting for future research to map this phenomenon using data from inhabitants on how hot they experience their residential environment to be. Research on improving public UGS can use quantitative methods to further explore what different groups of people desire from an UGS. This study has shown that older adults certainly can enjoy spending their day in a green environment, but not primarily in the public UGS as they are now available in Groningen. Systematically surveying what would convince people to go to a public UGS during periods of heat could find solutions to make these places more attractive to visit. Also interviewing older adults who do enjoy visiting UGS during periods of heat can provide more insights in what this group needs.

When it comes to preventing heat stress among older adults during periods of heat in urban areas, the potential of air-conditioning should not be overlooked. Most residential buildings in the Netherlands have no air-conditioning, while they can have a major role in increasing the indoor thermal comfort. Future research can investigate the potential of widespread air-conditioning in residential buildings for older adults, and the challenges with its associated costs and energy use.

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Appendix A: Informed consent form

rijksuniversiteit
groningen

Toestemmingsformulier voor deelname aan onderzoek

Titel van het onderzoek: De rol van groene plekken tijdens hete dagen voor ouderen kwetsbaar voor hittestress in Groningen

Onderzoeker: Nathan van Dam

Onderzoeksinstelling: Rijksuniversiteit Groningen

Studie: Economic Geography

Ik, ondergetekende, verklaar hierbij vrijwillig deel te nemen aan het hierboven genoemde onderzoek. Ik begrijp dat het doel van dit onderzoek is om meer inzicht te krijgen in hoe kwetsbare mensen omgaan met hittestress en in hoeverre parken en andere groene plekken daarbij helpen.

Ik begrijp dat mijn deelname inhoudt dat ik zal worden geïnterviewd en dat dit gesprek zal worden opgenomen met een dictafoon. Ik stem ermee in dat mijn antwoorden worden gebruikt voor dit onderzoek en dat de audio-opnamen zullen worden geanalyseerd om de doelstellingen van het onderzoek te bereiken.

Ik begrijp dat de audio-opnamen en de uitgeschreven transcripties alleen beschikbaar zullen zijn voor de onderzoeker, haar begeleiders en eventueel andere geautoriseerde personen die betrokken zijn bij het onderzoek. Ik stem ermee in dat mijn identiteit vertrouwelijk zal worden behandeld en dat mijn antwoorden geanonimiseerd zullen worden in publicaties of rapporten die voortkomen uit dit onderzoek.

Ik begrijp dat mijn deelname geheel vrijwillig is en dat ik op elk moment het recht heb om mijn deelname te beëindigen zonder opgaaf van reden. Als ik ervoor kies om me terug te trekken, zal ik een e-mail sturen naar n.r.van.dam.2@student.rug.nl en zal alle informatie die tijdens het interview is verzameld, worden verwijderd.

Ik verklaar dat ik de bovenstaande informatie heb gelezen, begrepen en ermee ingestemd heb.

Naam deelnemer:

Datum:

Handtekening:

Appendix B: Interview guide

- Informatie over de interviewee
- Gelegenheid geven aan interviewee om iets over zichzelf te vertellen
- Leeftijd
- Geslacht
- Woonsituatie
- Wat is uw gezondheidssituatie, op een schaal van 1 tot 10?

1.) Dagelijkse activiteiten

- Ik ben erg benieuwd naar hoe u op een normale, dus niet hete dag, uw dag indeelt om even een beeld te krijgen van u. Zou u me kunnen vertellen hoe een doorsnee dag er voor u uitziet?
  - Activiteiten, buitenshuis, binnenshuis, vervoer, met wie, wanneer, hoe lang
  - Welke rol speelt UGS in dit dagelijkse ritme?
    - Wat doet u daar en wat vindt u er fijn aan?
    - Is er een verschil tussen de winter en de zomer?
- Wat is de hoofdreden voor u om UGS te bezoeken?

2.) Beleving hitte en gedrag tijdens hete dagen

- Nu ben ik erg benieuwd hoe uw dagen eruitzien als het erg heet is. Ik kan me voorstellen dat uw dag er anders uitziet op een erg hete dag dan tijdens andere dagen.
  - Hoe ziet een dag er voor u uit als het erg heet is?
  - Over het algemeen, hoe ervaart u hete dagen? Positief of negatief?
  - Maakt u zich zorgen of voelt u zich angstig (of wanhopig) tijdens hitte?
  - Heeft u ook gezondheidsklachten die hittestress mogelijk verergeren?
    - Zo ja, ziet u zichzelf als kwetsbaar voor hittestress?
  - Kan de temperatuur in huis makkelijk aangenaam gehouden worden?

- Blijft u voornamelijk binnen of gaat u voornamelijk naar buiten tijdens hete dagen?
    - Welke plekken buitenshuis worden graag bezocht tijdens hitteperioden?
        - Parken, tuinen, andere groene plekken, open water, zwembaden winkels, tweede huis/tuinhuisje, iemand anders opzoeken. Goed doorvragen over alle plekken waar ze heen gaan naast UGS
            - →Nu eventueel doorvragen over UGS

    - Mogelijke activiteiten of pluspunten: rust, schaduw, onbekende mensen ontmoeten, vrienden ontmoeten, natuur, eenden, de vijver, wandelpaden, bankjes, activiteiten, vluchtoord tegen hitte, grootte

3.) Vervolg beleving hitte en gedrag tijdens hete dagen

- Tot slot ben ik nog benieuwd naar andere maatregelen die u neemt om minder last te hebben van hitte. Ik heb een lijstje met mogelijke aanpassingen die u kan doen, u hoeft alleen maar aan te geven of u dit wel of niet doet.
    - Draagt u andere kleren tijdens hete dagen?
    - Drinkt u meer?
    - Eet u anders?
    - Doucht u vaker?
    - Koelt u uw armen ook met water?
    - Gebruikt u wel eens een natte handdoek om te koelen?
    - Koelt u uw voeten ook met water?
    - Doet u de ramen open of juist dicht?
    - Gebruikt u dunner beddengoed?
    - Gebruikt u ook gordijnen of zonwering om de hitte tegen te houden?
    - Gebruikt u ook een ventilator?
    - Heeft u ook air conditioning?

Dat waren alle vragen die ik voor u had. Heeft u nog vragen of opmerkingen over ons gesprek?

Appendix C: Code book

Code	Definition	Purpose	Theme
Adaptive capacity	Participant describes their adaptive capacity to heat	Identifying how adaptive capacity shapes heat vulnerability	Heat vulnerability
Exposure to heat	Participant describes their exposure to heat on a normal day	Identifying how exposure to heat shapes heat vulnerability	Heat vulnerability
Sensitivity to heat	Participant describes their sensitivity to heat	Identifying how sensitivity to heat shapes heat vulnerability	Heat vulnerability
Coping mechanisms (not UGS)	Participant describes behavior to cope with heat	Identifying what coping mechanisms are used by participants	Coping mechanisms
Coping mechanisms (UGS)	Participant describes how UGS are used to cope with heat	Identifying how UGS are used as a coping mechanism during heat	Coping mechanisms
Description normal day	Participant describes a normal day	Identifying how normal days are different from hot days	Coping mechanisms
Motivations on using UGS	Participant describes why he visits UGS	Identifying what the reasons are to visit UGS, both during periods of heat and normal days	Coping mechanisms
Heat stress	Participant gives an example of heat stress	Identifying to what extent heat stress is experienced	Experienced heat stress