A thesis submitted to the Department of Environmental Sciences and Policy of Central European University in part fulfilment of the Degree of Master of Science

The evolving role of urban green spaces in pandemic-stricken cities: The impact of Covid-19 on the perception and use of green spaces in the city of Vienna

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ABSTRACT OF THESIS

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for the degree of Master of Science and entitled: The evolving role of urban green spaces in pandemic-stricken cities: The impact of Covid-19 on the perception and use of green spaces in the city of Vienna.

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The global Covid-19 pandemic has had an overwhelming impact on urban life and resulted in unprecedented changes in the way people work, move around the city and interact with each other. Beyond the need to limit the virus transmissions, the question of individual and social resilience and ability to cope with the adverse effects of pandemic measures has been raised. Urban green spaces have been suggested as one possible way to increase pandemic resilience in cities, considering their multiple benefits and services for people's physical and psychological health as well as social and community cohesion during a time of a crisis. This research aims to understand the impact of the Covid-19 pandemic on the perceptions and use of urban green spaces in Vienna. I conducted an online survey and explored changes in use of green spaces as well as people's needs, preferences and satisfaction with urban green spaces during the pandemic. Results showed that the use of green spaces in Vienna during the pandemic has increased among the surveyed population. The respondents used green spaces mainly for physical exercise, relaxing, stress reduction and observing nature. Moreover, frequenting green areas has been important to people's physical and mental health as well as for combatting feelings of isolation and loneliness. Results also showed that people were mostly dissatisfied about the high number of people that frequented urban green spaces in Vienna, making them overcrowded and thus reducing their value and benefits. A preference and need for more, larger and more natural green spaces has been indicated.

Keywords: Urban green spaces, Covid-19, public health, resilience, urban design.

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1. Introduction

From the beginning of the Covid-19 pandemic in March 2020, cities around the world have been the epicenters of the virus infections. High concentration of population and human activity has made cities particularly susceptible to high transmission rates of the virus and this has exposed the inherent vulnerabilities of cities to infectious diseases (Sharifi and Khavarian-Garmsir 2020). The policy measures that have been enacted to reduce the transmission rates have led to unprecedented changes in urban life with more than half of the global population living under some form of home confinement (Venter et al. 2020). These drastic behavioral restrictions coupled with the acute stress that the Covid-19 pandemic posed to millions of people have had a significant impact on people's psychological health and well-being (Wang et al. 2020; Brooks et al. 2020). During the early months of the pandemic in China, Wang et al. (2020) reported that more than half of the respondents to their survey, which comprised of 1210 people, stated that the psychological impact of the pandemic was moderate to severe and one third reported having moderate to severe anxiety. Beyond the obvious and immediate need to limit the virus transmission, this pandemic also raised the question of individual and social resilience in the urban setting where the pandemic restrictions have been the most severe (Berdejo-Espinola et al. 2021). With the ongoing pandemic and the likelihood of similar natural and anthropogenic crises occurring in the future, we need to understand how to future-proof our cities for an environment that promotes resilience as well as holistic health and well-being for everyone equally.

Green spaces and urban nature are a distinct feature of cities often associated with better health and higher quality of life (Kabisch *et al.* 2016; Twohig-Bennett and Jones 2018). Urban green spaces contribute to people's health and well-being through numerous pathways and mechanisms and their use during a stressful life event is believed to enhance psychological resilience and ability to cope with the adverse disturbances (van den Berg *et al.* 2015). These benefits of urban nature have been discussed well before the Covid-19 pandemic, but the most recent crisis amplified the validity of these arguments and given us a new lens to look at the importance of green spaces in our living environment. During the most stringent lockdown measures, urban green spaces have been one of the only public spaces accessible to people outside of their homes. The emerging research on this topic shows an increase in the use of green spaces in cities around the world and it inevitably raises the question on the role of urban nature in enhancing urban pandemic-resilience (Ugolini *et al.* 2020; Berdejo-Espinola *et al.* 2021; Venter *et al.* 2020; Geng *et al.* 2021).

During the first lockdown in March 2020, Austrian authorities initially prohibited the use of city squares and parks, a decision which was reversed shortly after following the public discussion on the importance of these spaces for urban residents (Gugerell and Netsch 2020). In Vienna, the urban parks and green spaces have therefore stayed open and have been used extensively throughout the pandemic (Winterer 2021).

1.1. Thesis Aims and Objectives

The aim of this thesis is to explore changes in perceptions and use of green spaces in Vienna during the Covid-19 pandemic. I conducted an online survey of Viennese population where I asked different questions on the use of urban green spaces before and during the Covid-19 pandemic. In the survey, I also asked about people's perceptions on green spaces, including questions on the importance of green spaces during day-to-day life during the pandemic as well as on preferences and satisfaction with existing urban green spaces in Vienna.

The objective of the research has been to look at the role of urban green spaces from the perspective of people's needs during the Covid-19 pandemic and to understand how these might enhance urban pandemic resilience and people's ability to cope with the pandemic. The research is situated within the frameworks of green spaces as one of the social and environmental determinants of health as well as people-centered approach to urban design.

1.2. Outline

The thesis starts with a literature review where I first give a definition of urban green spaces and shortly review the topic of green spaces as one of the determinants of health. I then give an extensive overview on multiple health-impact pathways and mechanisms by which green spaces and nature benefit health and human well-being, given that the thesis is based on this broad assumption on benefits of nature to humans. In this chapter, I also review the literature on previous pandemics in cities and how these have transformed how we look at public health within a built environment. Then, I give an overview on the literature that has been produced in the period of the past year and a half on the topic of Covid-19 pandemic in cities.

The third chapter will discuss the theoretical framework that underpins this research and how the topic of this thesis lies within the framework. In the fourth chapter, I outline the methods that I have used to create and distribute the online survey. I also discuss how I have gathered the relevant literature as well as analyzed the survey results. The fifth chapter presents the result of the survey. Here, the different sections address different parts of the survey such as changes in use, perception, preferences and satisfaction with urban green spaces in Vienna. Lastly, in chapter six I discuss the results of my research and draw conclusions on the role that urban green spaces have played for the surveyed population of Vienna and what this means for pandemic resilience.

2. Literature review

2.1. Defining urban green spaces

The concept of urban green space is used across many different disciplines without a unifying or harmonized definition of it. Studies that have researched urban green spaces often provide an operational definition of this concept which tends to vary depending on the context and discipline (Taylor *et al.* 2017). An overarching interpretation of urban green space used in scholarly work reviewed by Taylor *et al.* (2017) typically includes vegetated areas in an open urban space, such as parks, gardens, urban forests and urban farms. Moreover, this common interpretation also includes human use and influence as a necessary component of urban green space and it is typically discussed in terms of the value of such space to urban population. However, these interpretations are still very broad and leave plenty of confusion around what exactly constitutes urban green space. This is specifically the case with urban green and natural surfaces such as private and rooftop gardens, riverbanks, tree-lined streets and outside recreational and sport facilities.

In Europe, a common definition for urban green space used in scholarly work is provided by the European Urban Atlas under a code 14100 which defines Green Urban Areas as

"Public green areas for predominantly recreational use such as gardens, zoos, parks, castle parks and cemeteries (...). Suburban natural areas that have become and are managed as urban parks. Forests or green areas extending from the surroundings into urban areas are mapped as green urban areas when at least two sides are bordered by urban areas and structures, and traces of recreational use are visible" (European Commission 2016, 21).

In the category of Green Urban Space the Urban Atlas does not include private gardens within housing areas, rooftop gardens, vegetated areas along the streets and roads e.g. tree-lined streets, and patches of vegetated and agricultural areas that are not managed as a public green space (European Commission 2016). Moreover, water bodies and riverbanks are also not categorized as green space. However, the vegetated area along water bodies above the minimum mapping unit of 0.25 ha are classified as Green Urban Space. On the other side, the Urban Atlas has a separate category for Forests under a code 31000. This also applies to urban forests that fall under a municipal jurisdiction (European Commission 2016).

Given that major European cities use the data from the Urban Atlas and its categorization of Green Urban Areas (European Commission 2018), including the city of Vienna, the working definition for urban green space in this thesis will be based on the Urban Atlas data. Since I have identified urban and suburban forest as an important green space that was used by urban population during the Covid-19 pandemic, the Forest category will therefore also be included in the analysis. However, only forested areas that fall under the jurisdiction of the city of Vienna will be taken into account.

2.2. Determinants of health

The context of a person's life determines greatly their health and well-being, which is typically understood through the concept of determinants of health. According to the World Health Organisation (WHO), the main determinants of health are: genetics, gender, health services, social support network, physical environment, income and social status and education (WHO 2017). Access to green spaces and 'use' of nature falls under the category of social and environmental determinants of health. A number of studies have linked proximity and access to green spaces with improved physical and health conditions, including an overall lower mortality rates (Shanahan *et al.* 2015; van den Berg *et al.* 2015). Different health-impact pathways and mechanisms of green spaces and nature are associated with improved health and well-being which is discussed in further detail below.

2.3. Health impact pathways of urban green spaces

Many empirical studies have linked nature in urban areas with improved health and well-being and this evidence has been incorporated into urban planning agendas since the past century (Kondo et al. 2018; Corburn 2004). The United Nations Sustainable Development Agenda also incorporates the goal of improving access to "safe, inclusive and accessible green and public spaces" in cities under Goal 11 and target 7 (UN General Assembly 2015, 22). The aim of this section, therefore, is to give an overview of the existing evidence on the benefits of urban green spaces for health and well-being of the people residing in cities. I will do this by looking into different health-promoting mechanisms and pathways by which urban green spaces lead to improved well-being and health of urban dwellers, focusing also on specific health outcomes. The existing evidence overwhelmingly points at the benefits of green spaces and nature in urban areas, even when accounting for factors such as socio-economic status and other demographics. The main health impact pathways that stand out across literature are: air pollution and heat island effect mitigation, stress-reduction, relaxation and mental health, physical activity, social integration and improved immune system functioning. Although I have divided these different health impact pathways in individual sections, it is important to note that they rather 'operate' together and contribute to people's health and well-being in multiple and interacting ways.

Following a more general overview on the underlying mechanisms by which green spaces in cities improve health and well-being of people, I look at a more specific context of the most recent pandemic and the changes in the use of urban green spaces as a result of pandemic mitigation measures. However, before diving into the empirical evidence on urban green spaces benefits, I give a short account on the perspectives on human-nature relationship and how these might influence how we perceive and experience the benefits of green spaces.

2.3.1. Human-nature relationship

The discussion on the benefits of green spaces and natural environment for human health and well-being inevitably involves a need for a reflection on the relationship between humans and nature. This has been the topic of interest for many different disciplines for centuries – from philosophy and religion to evolutionary biology and social studies (Seymour 2016). However, it is beyond the scope of this thesis to provide a comprehensive overview of all the theories that explain the human-nature relationship and the impact of it on health and well-being. Instead, I want to acknowledge that these different theories on how and why humans derive health benefits from the natural environment exist and that they also influence how these benefits are perceived and experienced.

The primary distinction between the ways in which green spaces and natural environment provide benefits for human health and well-being lies in the causal pathways that lead to experiencing those benefits (Bowler *et al.* 2010). A number of theories suggests that nature has intrinsic qualities that offer direct health benefits to people because of the innate affiliation that humans have evolutionarily developed with the natural environment (Seymour 2016; Bowler *et al.* 2010). These theories can be organized under an overarching hypothesis of biophilia – a concept introduced in 1984 by Edward O. Wilson which suggests that humans have the innate tendency to affiliate and connect with living organisms and natural systems (Wilson 1984). This affinity, according to Wilson stems from our biology as creatures that have evolved with nature, learning to respond to natural stimuli in both positive and negative ways, e.g. in the case of phobias to dangerous animals and natural occurrences. Based on this intrinsic connectedness with nature, it is then suggested that natural environment improves psychological health, well-being and overall cognitive functions (Howell *et al.* 2011). Parting slightly from the evolutionary affiliation with nature but still emphasizing the direct benefits are the theories on restorative qualities of natural environment

stimuli which positively impact human health. Prominent theories include the Attention Recovery Theory by Kaplan (1995) and the Stress Recovery Theory by Ulrich (1983). The two theories suggest that natural elements have aesthetic and restorative qualities which, due to human's adaptive traits to nature, stimulate feelings of calmness, fascination and directed attention, leading to overall psychological well-being and stress recovery.

However, more recent studies on this topic have argued that the theories underlying evolutionary affiliation to nature and the resulting positive benefits for human health lack necessary empirical evidence (Seymour 2016; Joye *et al.* 2011). Instead, they suggest that the restorative effects of nature is based on the processing fluency – a term used to describe the ease at which external information is processed subjectively (Joye 2007). Based on the model of Perceptual Fluency Account of Restoration, Joye *et al.* (2011) argue that "*unthreatening natural scenes are affectively evaluated more positively than unthreatening urban scenes because our visual system more fluently processes certain aspects of the visual structure of the former than of the latter*" (266). Therefore, because the information is processing leads to positive affect, people experience restorative effects after spending time in nature. On the other hand, some studies have also argued that research on direct health and well-being effects of nature might be flawed because the observed benefits are often connected to subjective perception and expectations of those benefits by people who are already 'attracted' to nature (Seymour 2016).

The other most commonly identified causal pathway by which natural environment leads to positive health outcomes characterizes nature simply as a space that promotes healthenhancing activities and behavior which then result in well-being and health improvement (Bowler *et al.* 2010). This group of theories argue that green and natural areas provide space for and encourage physical activity – whose benefits for physical health, emotional well-

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being and psychological restoration are well established (Kaczynski *et al.* 2007; Blair *et al.* 2009). Therefore, the existence, accessibility and proximity of natural areas are correlated with increased physical activity as well as social participation (Street *et al.* 2007) which lead to greater social cohesion and overall improvement in health. However, comprehensive reviews of the added benefits of exercising and socializing in natural compared to synthetic environments for example, suggest that green spaces do have a beneficial added effect (Bowler *et al.* 2010). Those added benefit are typically manifested in terms of emotional and psychological well-being and reduction in what are generally perceived as negative feelings, e.g. anxiety, depression, sadness, anger, etc. (Hartig *et al.* 1991).

Although the health-promoting and well-being effects of natural environment are clearly established, the causal mechanisms and pathways by which nature offers these benefits are arguably often contested and explained by different theories. Nevertheless, there is enough ground on which we can establish the importance of having accessible green spaces in urban areas at any time, and particularly during a crisis such as the Covid-19 pandemic. The following paragraphs therefore present the evidence of the benefits of urban green spaces with more detailed information.

2.3.2. Air pollution and heat island effect mitigation

Air pollution is one of the biggest environmental and public health concerns faced by cities around the world (Ma *et al.* 2021). According to the latest World Health Organization (WHO) data, 91% of global population lives in areas where air pollution exceeds the safe health limit (WHO 2021). This has direct consequences for human health, since poor urban air quality increases the risk of cardiovascular diseases and leads to chronic and acute respiratory and lung diseases (Ma *et al.* 2021). Moreover, air pollution is expected to be the major cause for premature mortality globally by 2050 (OECD 2012). This indicates to an

urgent need to address air pollution in cities and urban vegetation has been given considerable attention as a potential nature-based solution for poor urban air quality (Manes *et al.* 2012; Kabisch *et al.* 2016). Modeling studies in cities around the world have shown that urban green spaces and urban forests improve air quality substantially (Nowak *et al.* 2006; Liu *et al.* 2012; Manes *et al.* 2012; Nowak *et al.* 2013). Trees and shrubs store and sequester atmospheric carbon by uptake through the leaves as well as deposition and retention of pollutants on plant surface (Nowak *et al.* 2006). This has not only obvious environmental benefits due to carbon and other green house gases sequestration, but also direct and indirect benefits for human health, given the contribution of poor air quality to global mortality rates and incidence of various chronic and acute diseases. Moreover, urban vegetation of any form might also reduce health-related inequalities and disparities by minimizing exposure to air pollution in communities that are residing in urban areas of historically lower environmental quality (Nœss *et al.* 2007).

Another important ecosystem service that urban vegetation offers is the regulation of microclimate and mitigation of urban heat island. Urban areas have a high rate of heatabsorbing surfaces such as roads, buildings and other built infrastructure that increases the average temperature. This contributes to the urban heat island effect and considerably higher temperatures in cities compared to surrounding rural areas (Arnfield 2003). In the light of increasing threats of climate change, urban heat island has become another major health concern particularly during extreme heat waves which are becoming increasingly more common (WHO 2016). Urban green spaces and urban forests lower the ambient air temperature by transpiration cooling as well as provision of shade (Vailshery *et al.* 2013; Nowak *et al.* 2006). During heat waves or more regularly on warm summer days green spaces in cities therefore offer a cooling effect that could significantly lower mortality rate in populations that are particularly sensitive to higher temperatures such as elderly (WHO 2016). On the other side, by providing shade urban vegetation can also decrease overall energy use of buildings, thus indirectly reducing atmospheric air pollution (Manes *et al.* 2012).

The evidence on air pollution and heat island mitigation potential of green spaces is based on models and data that are usually city or region specific. However, similar results have been produced in a number of cities around the world, which gives us confidence that the mitigating effects of urban vegetation can be expected in other cities as well.

2.3.3. Stress-reduction, relaxation and mental health

Above all other health impact pathways by which green spaces benefit people's health and well-being, stress-reduction, psychological relaxation and overall net positive impact on mental health have been given the strongest evidence so far (WHO 2016). These benefits are largely associated with the psycho-neuroendocrine responses to natural environment which lower the impact of stressors that are generally believed to cause chronic physiological conditions (Hartig et al. 2014). For example, green spaces in urban areas can buffer the exposure to stressful areas such as noisy traffic roads and crowding situations that act as constant stressors which increase body's sympathetic nerve activity (Nilsson et al. 2006; Park et al. 2007; Lee et al. 2011). Moreover, although nature directly reduces the amount and impact of stressors, it also provides positive restorative qualities (Hartig et al. 2014). A large amount of experimental studies have shown that spending time in natural areas enhances relaxation and restoration from mental fatigue leading to overall improved state of psychological well-being (Hartig et al. 1991; Ottosson and Grahn 2005). Furthermore, the existing studies have recorded reductions in self-reported levels of anxiety, anger, sadness, fatigue and an increase in levels of energy and attention (Bowler et al. 2010). Even a short walk in a vegetated area compared to a walk in built environment has been shown to reduce

the levels of cortisol – a hormone associated with stress, leading to relaxation and restoration (Roe and Aspinall 2011; Gidlow *et al.* 2016). Another study by Bratman *et al.* (2015) reported that a 90 minute walk in an urban green space reduced the neural activity in the subgenual prefrontal cortex, the area of brain that is linked to depression and anxiety.

In conclusion, there is an abundance of evidence that points at the beneficial effects of green spaces and contact with nature for mental health, stress-reduction and psychological relaxation. These benefits impact the overall health and well-being of people mainly by reducing chronic stress and fatigue which are known to lead to numerous adverse physiological conditions.

2.3.4. Physical activity

Physical activity and exercise have well-established benefits for physical and mental health across different population demographics (WHO 2010). Access to green spaces is, however, an important contributing factor to increased level of physical activity reported by studies in a number of countries (Kaczynski *et al.* 2007; Kaczynski *et al.* 2008; Epstein *et al.* 2006). Green areas provide space for exercise and promote physical activity and behaviors that reduce the amount of sedentary time (Sugiyama *et al.* 2013). Moreover, a review analysis on the relationship between physical activity and green spaces by Bowler *et al.* (2010) reported that exercise in natural environment provides added health benefits beyond simply provision of space. For examples, people tend to report a higher restorative experience when exercising in a natural environment compared to a more urban setting, even when doing the same exercise (Bodin and Hartig 2003; Marselle *et al.* 2013). Physical activity and exercise then lead to improved immune system functioning, cardiovascular health, reduced rates of obesity and lower morbidity rates of diseases such as osteoporosis, cancer and dementia (WHO 2010). The added benefit of exercising in a natural environment also positively

impacts overall mental health (Barton and Pretty 2010). On the other hand, it has been suggested that access and proximity to green spaces leads to greater behavior change in terms of more regular and consistent physical activity over time (Sugiyama *et al.* 2013). Other studies have reported that green spaces might promote active transport, i.e. walking and cycling, with the end-benefit both for health and environmental sustainability (Hartig *et al.* 2014).

2.3.5. Social integration

Another possible mechanism by which green spaces influence human health is by facilitating and fostering social contact. Social relationships, involvement and integration in a community are strong factors that predict life longevity and a variety of physical and mental health outcomes (Hawe and Sheill 2000). Most community and social interactions occur in indoor and outdoor public spaces, with parks and neighborhood green areas being the most common meeting point (Kuo et al. 1998). The presence of natural elements in a public spaces such as trees, grass, shrubs and water attract people to these spaces which inevitably leads to increased contact with other community members (Maas et al. 2009). Moreover, the quantity and quality of green spaces within a neighborhood have been associated with stronger perceived community ties, sense of community and individual feelings of acceptance and belonging (de Vries *et al.* 2013). The benefits of local green spaces might be particularly important in deprived communities and during the situations of crisis, such as a global health pandemic (Ward Thompson et al. 2016; Pouso et al. 2021). Communities going through a hardship have self-reported well-being, general health and reduction in stress if they had access to green spaces, and particularly allotment gardens (Ward Thompson et al. 2016). During the Covid-19 pandemic, when most indoor public spaces have been closed due to pandemic mitigation measures, urban green spaces and parks have been the only relatively

safe space where people can meet. In a situation that is already conducive to isolation and feelings of loneliness due to 'self-distancing' and isolation measures, access to green space becomes one of the few ways in which people can maintain social relationships and contact with the community (Pouso *et al.* 2021).

2.3.6. Immune system

While the majority of evidence on health benefits of contact with nature and access to green spaces rely on self-reported health outcomes and thus might have some credibility implications, Kuo (2015) has argued that the improved functioning of immune system is perhaps the central pathway by which nature benefits human health and well-being. Certain environmental factors in nature allow for exposure to microorganisms that are beneficial for the healthy functioning of the immune system, which in turns supports overall health (Kuo 2015). Moreover, Kuo (2015) argues that environmental biodiversity might boost immune health due to its effect on skin and gut microorganisms. Studies on 'forest bathing' in Japan have shown that regular and extended time spent in nature increased the number of anticancer cells and inflammatory proteins that are involved in chronic diseases that undermine the functioning of immune system (Li 2010; Mao et al. 2012). In turn, immune system plays a central role for human health, particularly when it comes to fighting infectious diseases such as viral infections (Kuo 2015). On the other hand, the functioning of immune system is sensitive to other specific health conditions, such as chronic stress and fatigue, which would in turn make the immune system the central accounting pathways for health benefits of contact with nature.

2.4. Urban green space characteristics related to positive health outcomes

Given the extensive evidence linking health and well-being with nature in urban areas, the information on specific features and attributes of those green spaces related to positive health outcomes is rather limited. A few studies have explored this topic and found relationship between the quality, size, attractiveness and tree canopy cover of an urban green space and enhanced health benefits. In a study of adults in Australia, Sugiyama et al. (2010) found that the size and attractiveness of a green space within a relatively close distance from one's home is more important than the existence of smaller green area within a shorter distance. Their study looked particularly at the physical activity of residents and how proximity, size and attractiveness of green space influence the level and amount of resident's physical activity. Attractiveness of a green area is the most important characteristic that enhances recreational walking of residents, where attractiveness was defined in terms of presence of walking trails, water features, lightning, exercise facilities, adequate maintenance and the type of surroundings (Sugiyama et al. 2010). They also found that proximity to an open green area was found to encourage any physical activity, but people that lived within 1.6 km distance from a larger and more attractive green space tend to engage in more physical activity that meets health guidelines – even if the areas was located at a greater distance. This study is consistent with a few other studies that found associations between the increased level of physical activity and the size, quality and attractiveness of green area (Epstein et al. 2006; Giles-Corti et al. 2005).

Similarly, the existence of specific facilities in a green space is also likely to determine the use and the amount of physical activity within that area. Facilities such as walking or cycling paths, wooded and water areas, lights along trails, bike and car parking as well as pleasant views were positively associated with higher physical activity (Schipperijn *et al.* 2013; Kaczynski *et al.* 2008). On the other hand, supporting amenities for physical activity such as outdoor exercise equipment, drinking water fountains, restrooms, etc. were found to not be as important determinants of physical activity (Kaczynsky *et al.* 2008). However, Aspinall *et al.* (2010) found that these supporting amenities such as restrooms and

benches in particular might be important for the elderly population and their use of green space for recreational and social purposes. Seating and resting opportunities in an urban green space were strong incentives for the older population to go outside and lack of these were found to significantly limit elderly's confidence to use the green area (Chastin *et al.* 2014).

Another attribute of urban green space that is associated with specific health outcomes is the density of canopy and tree cover. Jiang *et al.* (2014) found that higher tree cover density in an urban area induced greater self-reported recovery from stress and mental fatigue. However, this study also found that above a certain tree canopy density rate – namely above 34%, the stress recovery was slower. The authors explain this result by arguing that people tend to like both openness and greenness of a space, and in the case of urban green spaces this means having an open view to the sky along a surrounding moderate density of tree cover (Jiang *et al.* 2014). In addition, Kuo and Sullivan (2001) found that residents living in greener neighborhoods and with regular views on green natural elements reported lower levels of aggression, violence and mental fatigue than the residents living in more barren buildings. Furthermore, higher tree canopy density also comes with the greater mitigating effect of urban heat island and the reduced mortality rate of heat-related illnesses and emergencies (Tan *et al.* 2016).

2.5. Pandemics in cities

Urban living has a long history with pandemics. The high concentration of people residing in urban areas makes cities particularly vulnerable to infectious diseases and this is reflected in major disease outbreaks originating and accounting for the highest death tolls in historical urban centers (Sharifi and Khavarian-Garmsir 2020). However, it is believed that pandemics and contagious diseases have in fact shaped our cities to the form and modes of functioning that we know today (Gouveia and Kanai 2020). For example, the cholera

outbreaks in London and some US cities in the 18th and 19th century have been linked to contaminated water in cities which at that time had no sanitary and sewage system in place. The sewage was usually disposed in the open fields or the city rivers, such as the river Thames in London. Following the observations on how the disease spread in the city, it was concluded that the inadequate disposal of sewage was the leading cause of cholera infections (Newsom 2006). This resulted in an entirely new perspective on public health and its relationship with urban planning and urban services, ultimately leading to construction of sanitary and sewage systems in cities across the globe (Gouveia and Kanai 2020). Similarly, outbreaks of yellow fewer in New York and Philadelphia in the 18th century were partially linked to inadequate garbage disposal throughout the city that attracted wild animals from the surrounding areas, contaminating water and food that residents consumed (McNeur 2011). This too brought about sweeping urban planning changes such as zoning of urban area, waste management and construction of alleyways on streets that were initially primarily dedicated for garbage removal but that later became an essential part of public spaces used by pedestrians (Brinkley and Vitiello 2014). With more overcrowding in cities that exacerbated the tuberculosis infections, large cities such as New York recognized the importance of public spaces that provide fresh air and a possibility to avoid large crowds in the city (UN Habitat 2021). This resulted in the development of large urban parks such as the NYC Central Park that was thought out as another public health strategy to prevent disease outbreaks in the city (Arntsen 2019).

Moreover, previous pandemics have also brought about far-reaching societal, economic and political changes with long-term consequences (Blickle 2020; UN Habitat 2021). Perhaps most important change came with the consideration of public health as a societal goal that needs to be incorporated into urban planning (UN Habitat 2021). This led to a better understanding of the relationship between poverty, social justice and health, creating new housing programs for the poor that were particularly susceptible to infections. The new housing programs addresses both the access to basic housing but also decent living conditions. This involved appropriate lightning, ventilation and reduced number of people living in one apartment – all important factors that added to the rates of infections and disease spread (UN Habitat 2021). On the other side, some studies have also suggested that previous pandemics such as the Spanish influenza in the 1920s have sparked negative political sentiments towards certain groups of people believed to carry this disease (Blickle 2020). It has been suggested that this might have been one of the contributing factors in the increase of extremist voting in Germany in the 1930's that eventually led to the rise of the Nazi party to power (Blickle 2020).

These examples from the previous pandemics point out how the cities have historically been changed and transformed in efforts to address the faulty features of their design, form and way of functioning that have facilitated the outbreaks and spread of diseases. Although by now large parts of the world have the essential systems in places such as Water, Sanitation and Hygiene (WASH) services, around 2.4 billion people are still living without adequate sanitation facilities (WHO 2015). This was one of the major factors determining which regions were most affected by the Ebola outbreak in West African countries in the period between 2013 and 2016 (UN Habitat 2021). However, in more developed and wealthy countries with these essential services and systems in place, the focus during the most recent and ongoing Covid-19 pandemic has been rather on maintaining people's well-being and facilitating a relatively normal way of life considering the new measures in place. Reconsiderations on the use of public spaces have been at the center of 'Covid-proofing' of cities and these have been repurposed primarily for the use of people, either for walking, cycling or simply maintaining social contact in a relatively safe way (Campisi *et al.* 2020). Based on these initial and reactionary measures, we have experienced a

certain level of urban transformation caused by the need to mitigate and end the pandemic. This transformation might have been temporary given that they were part of immediate response measures. However, they have also been used as a lesson on the necessary changes needed for urban areas to become more pandemic-resilient in the face of imminent future outbreaks – as well as continuing Covid-19 pandemic (Sharifi and Khavarian-Garmsir 2020). The following paragraphs will give an overview on the major changes in urban life that resulted from the implemented measures and the urban transformations that have followed.

2.5.1. Covid-19 in cities

Given that the measures put in place to limit the virus transmissions have all been focused on reducing the overcrowding in cities and increasing social distancing between people, some cities have opened up public spaces typically used for car traffic and repurposed them for exercise, walking and cycling (Campisi et al. 2020). As a result, we have seen considerable changes in the way and how much people moved around the city. The public transport sector, for example, has seen a drop from 45% up to 85% in cities around the world, depending on the lockdown measures put in place (Campisi et al. 2020). Although the use of public transportation methods has later increased with the relaxation of measures during the summer months, more people have turned to cycling and walking as primary modes of commuting even after the end of the strict lockdown (Moraci et al. 2020). Similarly, the number of private vehicles on streets also increased, as urban dwellers considered this a safer option to the use of crowded public transport (Moraci et al. 2020). Many cities around the world have responded to these changes in urban mobility by converting streets and parking spots into pedestrian areas and installing pop-up cycling lanes (Campisi et al. 2020). By doing this, cities have addressed a multiplicity of issues. Firstly, the move from crowded motorized vehicles to cycling and walking has allowed for socially distanced travel and in

that way contributed to controlling the pandemic. Secondly, active travelling within city has mitigated the effects of social isolation and increased physical activity which had a positive impact on health and well-being of commuters (De Vos 2020). Finally, although temporary, these changes had an overall positive impact on urban environment given the improvements in urban air quality and conversion of car traffic streets to pedestrian areas (Sharifi and Khavarian-Garmsir 2020). Based on these changes in urban mobility that resulted from the pandemic mitigation measures, many have suggested that soft mobility and non-motorized urban transportation system are more resilient to pandemics and similar stressors (Sharifi and Khavarian-Garmsir 2020). They have not only facilitated social distancing when that was necessary at the time, but also provided an effective and accessible transport that is low-carbon and more stable in the face of uncertainties.

On the other side, Covid-19 pandemic has once again emphasized the importance of open and accessible green spaces in cities. As people living in urban areas adapted to the new lockdown measures, cities around the world have seen a significant increase in the use of parks and green areas for recreational as well social purposes (Venter *et al.* 2020; Geng *et al.* 2021). However, it is important to note that park visitations in different countries varied depending on the stringency of lockdown. For examples, countries that imposed strict stay-at home lockdowns in the first two months of the pandemic, such as Italy and Spain, observed a reduction in park visitations (Ugolini *et al.* 2020; Geng *et al.* 2021). Nevertheless, studies that monitored people's movement and park visitations over several months and through different lockdown measures, noted that the demand for green spaces in cities increased above the baseline average following the relaxation of lockdown measures. On the other side, in other countries such as United Kingdom and Germany, the park visitations increased with the stringency of government-imposed lockdown measures (Derks *et al.* 2020; Fisher and Grima 2020). This might be explained by the fact that these countries always allowed outside

movement for essential purposes, e.g. exercise and meeting people in small groups, regardless of the stringency of lockdown. In Oslo, for examples, Venter *et al.* (2020) observed a 291% increase in outdoor recreational activity during the 2020 lockdown period compared to the 3-year baseline average. They also observed greater activity in areas with higher green and tree canopy cover, as well as visitations of larger green areas outside the city. Across studies that conducted surveys, researchers noted physical activity, psychological relaxation and meeting people as the most common reasons for visitations of green spaces (Ugolini *et al.* 2020; Geng *et al.* 2021; Van Bavel *et al.* 2020). Beyond these individual examples and fluctuations in green spaces visitations, evidence across literature indicates that demand for green spaces increased globally and that it played an important role in maintain people's well-being during the pandemic.

Given the psychological burden and stress that Covid-19 posed to many people (Van Bavel *et al.* 2020), access to open green spaces during pandemics has been suggested to have the potential to increase psychological resilience of urban residents (Samuelsson *et al.* 2020). Green spaces allow for safe social interaction while at the same time facilitating social distancing. During the periods of social isolation and general psychological distress because of the pandemic, maintaining social contact has been an important coping mechanism for people. Access to green areas has provided space for these essential interactions and at the same time contributed to the reduction in virus transmissions, as outside spaces have been safer for interaction. (Geng *et al.* 2021). Moreover, and as discussed earlier in the literature review, urban nature is highly important for people's mental health and well-being regardless of the situation, and access to green spaces during pandemics has therefore been suggested to increase the overall coping capacity of people living in cities (Van Bavel *et al.* 2020).

3. Theoretical framework

This thesis is situated at the intersection of public health and urban design. More specifically, it looks into the benefits of urban green spaces within the framework of social and environmental determinants of health and from the perspective of people's needs, behavior and interaction with the built environment and their surroundings during the Covid-19 pandemic. It involves a goal of urban pandemic-resilience, although this goal extends beyond the current pandemic to any future uncertainties and crises that might compromise people's health and well-being in a city. If we understand cities as complex socio-ecological systems, this requires continuously responding to challenges with adaptive responses that would increase the coping and adaptive capacity of a city to deal with a multiplicity of uncertainties of the future (Du Plessis 2008). Planning for public health and resilience in a city then ultimately involves making decisions on urban planning and adequate approaches to urban design. Based on this reasoning on the implications of urban green spaces for public health and urban design, I framed my research under the theories on social and environmental determinants of health and people-centered approach to urban design.

3.1. Social and environmental determinants of health

Access to green spaces and urban nature is one of the key social and environmental determinants of health (Shanahan *et al.* 2015; van den Berg *et al.* 2015). Disparities in access to green spaces have been strongly linked to disparities in health, and this has been established before but also in the context of the Covid-19 pandemic (Lu *et al.* 2021). Green spaces in cities provide opportunities for physical exercise, psychological relaxation and social interaction which ultimately lead to improved health and well-being outcomes (van den Berg *et al.* 2015). Considering these real implications of nature for public health, elaborated in more detail in the literature review, it has been consistently reiterated that green spaces

need to be incorporated in public policy planning as a cost-effective solution to improving public health in cities (Shanahan *et al.* 2015). From the perspective of the Covid-19 pandemic, public urban green spaces have encouraged safe outdoor socializing and in this way limited virus transmission (Lu *et al.* 2021). On the other side, it has also been suggested that people living closer to green environments and spending more time in nature might have been better 'prepared' for the pandemic simply by having a higher baseline health. This, according to Lu et al. (2021), might have been one of the reasons for a high racial disparity in infection and mortality rates in the US during the Covid-19 pandemic.

3.2. People-centered approach to urban design

Different sustainability approaches have guided the development and design of cities in wealthy countries for several decades (de Jong *et al.* 2015). These efforts have been focused primarily on urban infrastructure aspects such as appropriate waste management, energy efficiency in buildings, improved access to public transport, etc. More recently the emphasis is also being given to societal aspects in the urban context such as quality of life and general well-being of urban residents (Bayulken *et al.* 2021). However, urban areas are increasing falling short of reaching these objectives (Buhaug and Urdal 2013). The share of global population living in cities is expected to increase to 7 billion by 2050 (UNDESA 2019). This influx of people living in urban areas comes with an increasing expansion of cities to surrounding natural areas, higher emissions of CO2 and other green-house gases, and an increase in other unsustainable consumption and production patterns (Bayulken *et al.* 2021). This ultimately results in poor environmental quality both in cities and more globally, affecting among other people's quality of life, health and well-being.

In the face of these environmental and social challenges as well as imminent future crises such as pandemics, it is an imperative to transform our cities to more sustainable and livable places. If we put people's needs at the center of this necessary urban transformation, one must start from looking at public life and people's behavior within an urban environment to understand how best to respond to those needs. From the perspective of the Covid-19 pandemic, this entails looking at the changes in public life that resulted from the pandemic and the measures that were implemented to limit virus transmissions (Stenfeldt and Risom 2020). This would allow us to understand what kind of urban design would be best at promoting health and people's well-being in a time of a crisis such as the most recent pandemic. Although different crises might require different approach to urban planning and design, green spaces could potentially offer multiple services that are effective in various crisis situations. This thesis therefore focuses primarily on people's interaction and use of urban green spaces during the pandemic in order to understand the role that urban green spaces might play in enhancing resilience and people's well-being during the pandemic. A better understanding of this might then give us an insight into strategies that could increase resilience and coping capacity of cities and urban residents in the face of future environmental, social and health crises.

4. Methodology

4.1. Literature review

The literature review for this thesis was conducted using the snowballing approach as well as database search based on the predetermined key words. The first part of the literature overview that reviewed the benefits of nature and urban green spaces for human health and well-being is based on the backward snowballing sampling method. Three review papers were selected as a start from which further relevant peer-reviewed articles were identified and included in the literature review. The starting papers – (WHO 2016; Seymour 2016; Kondo *et al.* 2018) – were selected because of their relevance to the topic of this thesis, high citation rates and because they provided a systematic overview of the topic. Moreover, a report by the World Health Organization that reviewed evidence on urban green space and health was selected because of the authority and standing of the organization. The snowballing approach to this literature review identified a significant overlap in literature that the starting papers referenced which I believe points at the validity of the review.

The second part of the literature review covered the history of pandemics in cities and changes as a result of the Covid-19 pandemic, using Scopus. The search string used to obtain literature was TITLE-ABS-KEY (("Covid-19") AND ("Cities" OR "City" OR "Urban") AND ("Resilienc*") AND ("Planning" OR "Design")). This part did not focus only on urban green spaces because the aim was to map the overall changes in urban life due to the pandemic. Moreover, I included the key word *resilience* because the aim was to look at these changes and transformations from the perspective of urban resilience. The selected peerreviewed articles were then analyzed and the key aspects discussed were reviewed and presented in the literature review.

The reasons for using different literature review method for the two parts of my literature review are the following. Firstly, the topic of urban green spaces and more broadly nature and human health is notably a big field of research with large amount of evidence that dates back to the beginning of the 20th century. Attempts at database searches on this topic have produced more than 2000 results (e.g. Scopus database). Because of that, I decided to use the snowballing approach and rely on already existing systematic reviews on this topic in order to encompass all relevant literature. On the other hand, the topic of the Covid-19 pandemic and changes in urban life that resulted from lockdown and other mitigation measures is clearly new and only one and a half years old. Although it is a topic that has already been given considerable attention, the amount of existing literature is not very high which allowed for a systematic database search. However, a comparison between the number of peer-reviewed articles that the same search string yielded in the period of half a year indicates that is an increasingly important and growing area of research (in December 2020 the same search string produced 26 results, whereas at the time of writing this thesis in June 2021 the result increased to 77 articles on Scopus database).

4.2. Online survey

4.2.1. Data collection

The questionnaire used in the survey was adapted from an international exploratory study that mapped changes in use and perception of public and green spaces in several European countries (Ugolini *et al.* 2020). The entire questionnaire can be found in Annex I. The survey was targeting only the inhabitants of Vienna and this was reflected in several questions in the questionnaire. The survey was distributed entirely online using different social media and communication channels. The large majority of responses came from Facebook users given that the survey was distributed in various local Facebook groups.

Examples include different Vienna district groups, e.g. *Wir wohnen im 10. Bezirk¹* (a separate Facebook group exists for each district in Vienna), and student groups, e.g. Uni Wien Studentinnen und Studenten². Moreover, the survey was also shared with personal contacts living in Vienna or with connections to Vienna who then further shared it within their network.

4.2.2. Data analysis

The results of the survey were first transferred into an Excel file and analyzed using Excel tools to perform descriptive statistics. The primary tool used were Excel Pivot Tables in order to create summary statistics for each part of the questionnaire. In cases where a question had a quantitative answer, e.g. question 3.13 (*How much do you agree with the following statements?* (*1 not at all – 5 very much*), the Excel function AVERAGE was used to calculate the mean of the data set. The results were then represented in graphs and charts. Textual response to open-ended questions in the survey were coded manually and assigned different categories.

Following the basic and summary data analysis, I then looked into patterns and correlation between multiple variables, i.e. questions. For this purpose, I used the programming language Python. I first imported the data into the program and then coded the answers in order to have a numerical value for each answer. For example, in questions 2.2. and 3.6. - "*How far is the green area that you visited before/during the pandemic*", the respondents were given three possible answers. Each of these answers were coded into a number so that *Less than 500m* = 1, *Between 500m and 1km* = 2, *More than 2km* = 3. The rest of the dataset was coded in the same way. Next, I assigned a median value to all missing data points, i.e. in cases where people gave no answer to a specific question. Considering that a

¹ Link to the Facebook group: <u>https://www.facebook.com/groups/1087609214600232</u>

value was missing in only a few cases, assigning a median value did not make a notable difference when computing the correlation matrix. Important to note is that not all questions were included in the correlation matrix. Some questions and their answers could not be easily ranked and coded into numbers and they were therefore left out from the correlation analysis. Nevertheless, most questions were included. The correlation matrix was visualized in the form of a heatmap, and a total of 24 questions were analyzed. The values of correlation are -1 to 1, where -1 indicates negative or inverse correlation, 0 indicates no correlation and 1 indicates high correlation between variables. In the heatmap, the lighter color represents higher correlation, which becomes darker with lower and more negative correlation.

4.3. Limitations

During the data collection process I encountered difficulties with distributing the survey to a representative sample. Given that the survey was distributed primarily online and through social media platforms such as Facebook, the sample was limited to the population that uses these platforms of communication. Moreover, the way this online survey was distributed might have targeted primarily younger people as well as those previously interested in the topic, leading to self-selection bias. These difficulties were certainly expected as it is the case with most surveys, and I tried to mitigate these limitations by sharing the survey in a variety of Facebook groups with the effort to reach a diverse group of respondents. Important to note is that the ongoing Covid-19 pandemic prevented me from using different methods of data collection as close contact with people was still limited and highly discouraged.

Another limitation is related to the data analysis process. It is important to note that in computing correlation matrix errors can occur when complex textual statements are coded

² Link to the Facebook group: <u>https://www.facebook.com/groups/875671672480093</u>

into simple numbers. Thus, the correlation matrix and its heatmap might look slightly different depending on how one converts textual responses into numbers. For example, coding Yes=1 and No=0 will give a slightly different correlation values with other variables than Yes=2 and No=1. I have addressed this issue by trying to have as much consistency as possible in the way responses were coded. Still, the correlation numbers represent an approximation and not a definite truth. Moreover, they represent an existence of a relationship and a trend, not necessarily a cause and effect relationship between different variables.

Ultimately, it is important to note that the results of this survey reflect the opinions of majority younger people and mostly those with a university degree. Moreover, as is often the case with surveys, the people choosing to respond to it are quite likely people with an existing interest in the topic which might have led to a self-selection bias. Therefore, the results of this survey represent only the opinions and conclusions on the sampled population and cannot be assumed for the entire population of Vienna.
5. Results

5.1. Survey sample characteristics

A total of 104 responses were collected through the online survey. Given that the survey targeted only residents of Vienna, 2 responses were initially removed because the respondents indicated that they do not live in the city. Therefore, the final sample consisted in 102 responses that were included in the data analysis.

The respondents to the survey were 71% female, 28% male and 1% other. The age of the respondents was more representative than expected, given that I anticipated to have a large majority of younger people responding to the survey because of the way that the survey was distributed. In the final sample 34% of respondents were 20 to 29 years old, 19% 30 to 39 years old, 17% 50 to 59 years old, 14% 40 to 49 years old, 12% 60 to 69 years old and finally 4% of the respondents were 70 to 79 years old. The representation of different age groups in the survey is likely a result of the survey being distributed in various Vienna neighborhood groups on Facebook whose members are mostly people above 30 or 40 years old who follow and engage in the groups. On the other hand, given that the survey was also distributed through a personal network of typically younger contacts, the majority of respondents were still in younger age cohorts. Regarding employment status, the majority of respondents reported being fully employed (46%), followed by students (20%), retired (18%), having a free-lance job (13%) and unemployed (3%). The majority of respondents. 61%, reported having a university or college degree (Universitäts-/Fachhochschulabschluss in German). This is followed by 22% having an Apprenticeship training (Ausbildung), 14% having completed high school as the highest education level and 3% holding a post graduate degree.

5.2. Use of UGS before and during the Covid-19 pandemic

59% of the respondents reported that their overall visitation to urban green spaces in Vienna increased during the Covid-19 pandemic. 30% reported using green spaces at the same level as before the pandemic and 11% of respondents reported that their use of urban green spaces decreased as a result of the pandemic. Respondents were also asked *how often* they used to visit green spaces before and during the pandemic and the results show that the frequency of their visits also changed. People who reported visiting green space more than once a week increased the frequency of their visits by 35% during the pandemic (Figure 1.). In contrast, the number of people who visited green spaces once a month halved as a result of the pandemic. Visitations to green spaces several times a month and once a week also slightly decreased. This shows that the overall use of green spaces more often than before the start of the pandemic. However, this increase is due largely to the increased use of green spaces by those who have been using them with higher frequency.



Figure 1. Frequency of visits to green spaces, before and during the Covid-19 pandemic.

The age of the respondents seems to influence the use of green spaces during the pandemic. Older people were less likely to increase their visitation and use of green spaces

during the pandemic (Figure 3. (3.11 ; 5.2)). Similar results have been observed by Berdejo-Espinola *et al.* (2021) in their case study on urban green space use during Covid-19 in Brisbane, Australia. This might be explained by the greater health risk that the older people face by going outdoors, given the higher mortality rate to the virus above the age of 65, which reflected also on people's use of green spaces.

The majority of survey respondents reached the green area by foot, both before and during the pandemic. However, there was an increase in people reaching green areas by car and a decrease in people using public transport and bike (Figure 2.). These changes in the way that people move around the city, either to visit green areas or for other purposes, have been observed in cities around the world and are quite consistent among various studies (Moraci *et al.* 2020; Campisi *et al.* 2020; Ugolini *et al.* 2020; Sharifi and Khavarian-Garmsir 2020).



Figure 2. How did people reach green spaces before and during the pandemic?

When it comes to changes in the use of different transport methods, people used public transport less often during the pandemic in order to avoid crowds and to minimize the risk of getting infected. Moving around either by foot or car was therefore a preferred mode of transport as these were perceived safer. According to a study by the City of Vienna, two thirds of Viennese population lives within 250 meters from the closest green space (Stadt Wien 2013). In addition to Vienna being a relatively pedestrian friendly city, it was therefore anticipated that the majority of people reach green areas by foot – even though people might not use the closest green area to their place of living. On the other hand, as the visits to green spaces on the urban periphery as well as outside the city increased during the pandemic, this might have also contributed to the increased use of cars, as these were not less accessible by public transport.

On the correlation matrix heatmap (Figure 3.), we see a strong inverse correlation between distance to the green space that the respondents typically visited and the frequency of their visits. Namely, the further the green space from people's place of living, the less frequent the visits (3.2; 3.6) & (2.2; 2.5) in Figure 3. This correlation was observed both before and during the Covid-19 pandemic and it is consistent with the existing and overwhelming evidence that links the access and proximity to green areas with more frequent use and generally a more active and healthy lifestyle (Coombes *et al.* 2010; Neuvonen *et al.* 2007).

The most common type of green space that the sampled population visited both before and during the pandemic was an *urban park*. The second most preferred type of green area is a *green space on the periphery* of the city. However, there was a significant increase in people visiting *green spaces outside the city* during the pandemic and a slight decrease in visitation of urban parks as a preferred type of green space. Vienna's green spaces have been overcrowded throughout the pandemic, causing a general dissatisfaction among the population, also reflected in this survey, and a public discussion that raised a question whether the city has enough green spaces for everyone (Winterer 2021). This again points at the important role that green spaces in the city have in a time of a pandemic, given that so many people have found refuge in urban nature for various purposes. Moreover, these results reflect the general tendency of people to avoid crowded places in the city and seek more natural areas with fewer people, as they are perceived to be safer, more natural and thus offering more benefits in terms of psychological relaxation and stress recovery. Ultimately, the results of this survey and more generally the experience of living through a pandemic for more than one year now, raise the question of crowding and density in urban areas. Although urban density opens the way to more environmental sustainability, it inevitably comes at a cost of lower quality of life and in this case more difficulty in reducing the virus transmission and mitigating a global pandemic.



Figure 3. Correlation matrix heatmap. In the heatmap -1 indicates negative or inverse correlation, 0 indicates no correlation and 1 indicates high correlation between variables. The labels on the x and y axis represent the number of question in the survey. The bright diagonal line from top left to bottom right represent correlation between each question itself, which is equal to 1 as every questions is 100% correlated to itself. The list of questions is provided in the table on the next page.

in the heatmap	
2.2	How far did you travel to reach the green area that you visited most frequently?
2.5	How frequently did you typically visit this green area?
3.2	How frequently do you typically visit this green area (to the extent allowed) during the period of lockdown?
3.4	Is this the same area that you most frequently visited before the Covid-19 lockdown?
3.6	How far is the green area that you currently visit most often?
3.9	During the lockdown do you prefer to visit green areas in the city or outside the city?
3.11	During the Covid-19 pandemic, did your visitation to green areas decrease or increase?
3.12	Is access to green areas more important to you during the Covid-19 pandemic than before?
3.13a	Visiting green areas improved my physical health during the lockdown
3.13b	Visiting green areas improved my mental health and well-being during the lockdown
3.13c	Green areas improve public health
3.13d	Frequenting green areas during the pandemic makes people less lonely and isolated
3.13e	Green areas are important for meeting people while having to socially distance
4.1a	Satisfaction level: Presence of recreational facilities (playground/exercise equipment)
4.1b	Satisfaction level: Quiet/freedom from noise
<i>4.1c</i>	Satisfaction level: Aesthetic appearance
4.1d	Satisfaction level: Natural value
4.1e	Satisfaction level: Presence of wild animals
4.1f	Satisfaction level: Variety of vegetation
4.1g	Satisfaction level: Equipment for relaxing (e.g. picnic tables/benches)
4.3	Is there a green area closer to where you live but that you did not frequent during the lockdown?
4.5	Do you think Vienna has enough green areas in the city?
5.1	Gender of the respondent
5.2	Age of the respondent

Survey question

Table 1. The list of survey questions that inform the heatmap.

No. of question

To the questions whether they visited the same green area before and during the pandemic, 68% of respondents reported that they visited the same area, as opposed to 32% of respondents who stated that they visited a different green space during the pandemic compared to before. The respondents could explain why they frequented a different area, and their answers were coded which led to three main categories, i.e. reasons, to stand out. The most common reason for using a different green space during the pandemic was it being *closer to the place of living*. The measures introduced to reduce virus transmission during the pandemic changed people's lives drastically. Perhaps the biggest change was that people were confined to their homes, where they studied and worked from. Because of that, respondent reported staying closer to their homes instead of commuting to a different part of the city where they might be usually using the green areas during or after work, university, etc. On the other hand, the preference for using green spaces closer to one's place of living might also be connected with a sense of safety and reduced risk of infections, given that the commuting time was significantly reduced. This then allowed people to reach their preferred green area by foot or bike. Furthermore, the respondents also reported frequenting a different green space during the pandemic because it is bigger, more natural and has fewer people. This is again consistent with other answers to the survey where the respondents reported preference for larger green areas in order to avoid crowds and 'get more of out nature'. Finally, people also stated *relocation* to a new place of living as a common reason for frequenting a different green space, which in turn reinstates previous preference to use green spaces closer to the place of living.

In the survey, people were also asked to state the main reasons for visiting a green space, both before and during the Covid-19 pandemic. They could choose a maximum of three reasons, among the following: *Meeting people, Physical exercise, Taking the kids outdoors, Reading, Observing nature, Taking the dog out, Relaxing and stress-reduction.*

Among the top three reasons for visiting a green space both before and during the pandemic were *Relaxing and stress-reduction, Physical exercise and Observing nature*. However, during the pandemic there was an increase of 32% in people choosing *Observing nature* as one of the main reasons for the use of green spaces, a 9% increase in *Physical exercise* and 3% increase in *Relaxing and stress-reduction* as the main reasons for the use of green spaces during the pandemic. Furthermore, *Taking the kids outdoors* also increased by 10%. On the other hand, the number of respondents choosing *Taking the dog out* as one of the main reasons stayed the same, as the pandemic did not influence how often a dog needs to be taken out for a walk. Certainly, an interesting change that resulted from the pandemic is the number of respondents choosing nature observation as one of the main reasons for visiting green spaces. This takes us back to the literature review and various theories on the psychological effects of being in and observing nature and its benefits for people's well-being. Although based on this survey we cannot directly infer that people visited green areas to observe nature and thus increase their psychological well-being, we might hypothesize that this was the desired effect that made people observe nature more during the pandemic.

5.3. Preferences and satisfaction with UGS

One section of the survey was targeted particularly to find out about people's satisfaction and preferences for urban green spaces during the pandemic. The majority of respondents prefer to visit green spaces on the periphery of the city (39%), followed by a preference for green spaces in the city (37%) and green spaces outside the city (24%). The respondents were asked to elaborate on the reasons for such a decision, which was again coded and categorized. The main reasons why people prefer to visit green space on the periphery as well as outside the city is because it provides *greater natural value and restoration effect* and because it is *bigger, calmer and has fewer people*. On the other hand,

the main reasons that make people choose to frequent green spaces in the city are them being *easier to reach by foot, bike or public transport*, and also because they allow for regular visits throughout the week. In contrast, although many respondents stressed out the preference for bigger, calmer and more natural green areas outside or on the periphery of the city, they reported that these require more time to reach and usually cannot be visited on a regular basis during the weekdays.

The textual responses provided further valuable and more detailed information on people's preferences and needs when it comes to green spaces during the pandemic. Throughout the survey, what stand out the most is that people preferred larger and more natural green spaces. More natural was typically defined as a green space with higher treecover and higher natural value. These were perceived as being safer from the perspective of reduced likelihood of getting infected. Moreover, the respondents also stated that bigger and more natural green areas, with less noise pollution and fewer people provided an increased level of psychological relaxation and stress recovery, which was important to them both before and during the pandemic. The respondents also prefer bigger green spaces on the periphery of the city because they usually have a greater variety and difference in elevation (specific to Vienna). This feature reportedly allows for a more dynamic and effective physical recreation, which as mentioned earlier was among the most commonly stated reason for visiting green areas. On the other hand, among the surveyed population the biggest dissatisfaction regarding green spaces in Vienna during the Covid-19 was the overcrowding. Crowds of people in green areas have been perceived to reduce the value and benefits that people usually get from visiting urban green spaces. Furthermore, respondents expressed the need for a better access to green area by pedestrian and cycling paths, and stressed the need to reduce road traffic throughout the city.

To the question of what they would improve in green spaces that they frequented during the pandemic, the most common response was: *Elements for relaxation (e.g. benches and tables), Waste collection/cleanliness, Level of noise pollution and Areas for sports and recreation (e.g. playground/exercise equipment)*. In addition, the respondents also stated that they would prefer to have more and better services and amenities such as toilets, water fountains and dog-friendly areas. Moreover, several respondents expressed dissatisfaction with the opening hours of certain green spaces in Vienna that allowed restricted access especially to people who work throughout the day. For example, the park Schönbrunn, which was the most commonly visited green space by the sampled population, has very restricted hours especially during wintertime (6:30AM to 5PM). Other historical and cultural parks within the city have similar opening hours which restrict open access to people at any point of the day or night. Such restricted access might diminish the value of green spaces in the city and perhaps lead to even more overcrowding of other open green spaces during the pandemic.

Respondents were asked whether Vienna has enough green spaces in their opinion, and the majority responded that *it could have more* (64%). The rest, 36%, responded with a *yes*. In the open textual responses, some respondents made remarks on the current plans to redevelop a part of the Naschmarkt area into an indoor food market (*Markthalle*). This has been a topic of heated public discussion in Vienna for several months, with various political and activist groups campaigning for keeping this an open public space and developing a green space instead (Winkler-Hermaden 2021).

5.4. Perceptions on UGS during the Covid-19 pandemic

One question of the survey asked the respondents to rate how much they agreed with a given statement (1 for *not at all* and 5 for *very much*). Here, the age of the respondents was

inversely correlated with their responses (Figure 3.). Younger people in the age of 20s and 30s on average agreed more with the following statements: 1. Green areas are important for meeting people while having to socially distance, 2. Frequenting green areas during the pandemic makes people less lonely and isolated, and 3. Visiting green areas improved my mental health and well-being during the lockdown. On the other hand, the older the respondent, the less likely they agreed with these statements. These differences in age perhaps reflect different living situations of younger people. People in their 20s and 30s are more likely to live alone and thus have the need to go out of their homes in order to have social contact, whereas older people usually already live with their families and partners. During the pandemic when most indoor places are closed and considered unsafe, open and green areas are some of the remaining spaces where people can still meet in order to keep social contact and combat feelings of isolation and loneliness. When it comes to the statement on mental health and well-being, the age difference in agreement might be due to the greater awareness of mental health among younger generations. Across all age groups, the respondents tend to agree equally with the statements: Visiting green areas improved my physical health during the lockdown and Green areas improve public health.

The majority of respondents (60%) stated that access to green spaces during the Covid-19 pandemic was more important to them than before. 39% of respondents reported that access to green spaces was equally important as before the pandemic, and 1% stated that it was less important. Individual perceptions on the benefits of green spaces seemed to be a predicting factor for how often people frequented green spaces during the pandemic and vice versa. For example, the more often people visited a green space, the more likely they were to agree with the statement on physical and mental health benefits of visiting green spaces during the pandemic, (3.2 ; 3.13a-b) in Figure 3. Similarly, respondents whose visitations to green spaces increased during the pandemic and who stated that visiting green spaces was

more important to them during than prior to the pandemic, were also more likely to agree that this benefited their physical and mental health, (3.11; 3.13a-b) and (3.12; 3.13a-b) in Figure 3.

6. Discussion

The objective of this thesis has been to look at the role of urban green spaces from the perspective of people's needs during the Covid-19 pandemic. However, the value of green spaces goes back to well before and beyond the most recent pandemic. It is well-established that green spaces and urban nature benefit people's health and well-being through different pathways, such as opportunities for increased physical activity, stress reduction and psychological relaxation, air pollution mitigation, etc. (WHO 2016). Being one of the key social and environmental determinants of health, access to green spaces in cities has real implications when it comes to disparities in health among different groups of population (Lu *et al.* 2021). The Covid-19 pandemic has given us a new lens to look at these benefits and more broadly at the role of urban nature during a global crisis which has shaken the very foundations of our understanding of normal life.

With the measures that have been introduced to limit virus transmission, the daily life of urban dwellers has been drastically changed. In Vienna, city parks and other green spaces have been some of the few openly accessible public spaces where people could go outside of their homes. Through this research I wanted to understand how people used these open green spaces, how they perceived them from the perspective of the ongoing pandemic and what role they played in helping people cope with the adverse effects of the pandemic and measures such as social isolation, loneliness, stress and other strains on mental as well as physical health. The survey that has been conducted as part of this thesis has shown that the use of green spaces during the Covid-19 pandemic in Vienna has increased among the sampled population. Respondents visited green spaces more frequently than prior to the pandemic, with the majority reporting visiting green spaces more than once a week. These results show that urban green spaces have been and are important part of people's life. Nevertheless, there are differences in green space use depending on people's age group. Older people among the respondents were less likely to increase their use of green spaces during the pandemic, most likely because their perceived health risk of going outside was higher. This has important implications for ensuring that green spaces are equally accessible to people of all age. Older people, especially those living alone, are extremely dependent on urban green spaces for social interaction and community engagement (Chastin *et al.* 2014; Maas *et al.* 2009), and it is important to make these a safe space for them even during the time of a pandemic.

The sampled population has used green spaces primarily for physical activity and exercise, relaxing and stress reduction and for observing nature. During the pandemic, observing nature has increased as one of the major reasons for visiting and spending time in green spaces among the respondents. The respondents have used green spaces for other important purposes as well. Taking the kids outdoors, walking a dog as well as meeting people have ranked high among the reasons for visiting green spaces. The results of this survey are consistent with other studies that have surveyed green space use during Covid-19 in cities around the world (Ugolini *et al.* 2020; Geng *et al.* 2021; Van Bavel *et al.* 2020)

The majority of respondents also expressed that visiting green spaces has been even more important for them during the pandemic than before. Younger people especially, perceived urban green spaces as important for their mental health, for combating the feelings of social isolation and loneliness as well as for meeting people in a safe way. These differences in age might be a result of higher awareness among young people on these issues but also because of different living situations. Nevertheless, across different age, respondents regard urban nature as an important component of public health and healthy and quality lifestyle. After conducting a similar survey across different countries, Ugolini *et al.* (2020) suggested that "*this could be an indicator of the special biophilic importance that greenery has for city dwellers, above and beyond the need for open space such as may be found in a public square that is relatively devoid of vegetation*" (8).

We could then say that green spaces have played an important role in increasing urban resilience during the Covid-19 pandemic. The urban pandemic-resilience here is understood mainly in social and psychological terms, i.e. the resilience of people to cope with the pandemic beyond merely surviving the infection once the virus is contracted. Pandemic resilience also involves maintaining mental health and well-being as well as limiting and reducing virus transmission in order to stop the spread of the disease. The pandemic has disrupted our way of interacting and connecting with people, an extremely important factor in people's well-being and overall health. Green spaces, once again, have provided an opportunity to meet people and keep social ties in a way that does not drive infection rates further up, but that at the same time helps people cope with the existing situation. On the other hand, respondent's clear dissatisfaction with overcrowded green spaces in the city also indicates that urban nature represents a safe refuge for people, which is compromised and diminished in value when a certain threshold of visitors is reached. This ultimately demonstrates the need for more green spaces in the city in order to accommodate the increasing number of people who seek refuge in them for various purposes and for increasing overall pandemic-resilience. Other solutions to the problem of overcrowding might involve controlling access to green spaces and imposing stricter social distancing rules – if these can be at all implemented and controlled outdoors. However, such measures, particularly limiting access to green spaces would surely be controversial and problematic, as equal, open and regular access to urban nature has been so important for people's well-being during the pandemic.

6.1. Implications for the future

Going back to this thesis' framework on people-centered approach to planning resilient cities in the face of pandemics, the results of this survey have given us some clues on what are people's needs and preferences when it comes to urban green spaces. As expected, the majority of respondents have visited urban parks both before and during the pandemic. This has been the preferred type of green space, because it allows people to access it easily on foot, by bike or via public transport. However, many respondents preferred to use green spaces on the periphery as well as outside the city for multiple reasons. Green spaces on the periphery of the city are perceived to have a higher natural value and are typically larger. This provides a better setting for relaxation and stress reduction as well as physical activity. Moreover, these areas are also perceived safer from the perspective of infection risk as they offer more space for people or simply have fewer people visiting, i.e., there is lower visitor density. Smaller green spaces offer little value to people in terms of benefits that they typically seek from visiting green areas. Instead, there is a preference for larger green spaces with higher tree-cover density in particular, as these characteristics are usually related to positive health outcomes and increased benefits of green space use, which has been observed in previous studies on this topic as well (Jiang *et al.* 2014; Van Bavel *et al.* 2020; Geng *et al.* 2021).

Vienna is a city where green spaces on the periphery as well as outside the city can be easily reached, typically under 30 minutes by public transport (Stadt Wien 2013). However, as the city's population grows, its green spaces will need to accommodate an increasing number of people. On one side, the city needs to increase the number of any kind of green space, in terms of size and type, in order to ensure equal access to all population. This entails tree-lined streets as well as small neighborhood parks that are easily reached by foot and that have a value beyond health benefit, e.g. mitigating urban heat island effect. However, more emphasis will have to be put on the quality and structure of these green spaces. This would mean ensuring that large nature hotspots within the city exist and that they can be reached easily and on a regular basis. If we look beyond the case of Vienna to even bigger cities and urban regions, having large natural areas within the city limits becomes especially important. However, allocating free space in cities to nature clearly competes with the need for more housing and accommodating the growing urban population. This has been a challenge already before, but as cities and global urban population grows, it will be even more important to understand how to integrate more nature in our built environment in a way that truly benefits people.

7. Conclusion

This thesis has explored changes in the perception and use of green spaces in Vienna during the Covid-19 pandemic. The benefits of urban green spaces for people's health and well-being have been widely discussed well before the most recent pandemic. However, the experience of living through the Covid-19 lockdowns with varying stringency over the past one year and a half has put urban green space into spotlight and amplified the validity of arguments on their multiple benefits. The pandemic has changed the way we move around the city, use public spaces and interact with other people. Urban green spaces in cities around the world have been extensively used as one of the few openly accessible public spaces considered to be relatively safe to use.

With this research, my objective has been to understand how green spaces have been used in Vienna, what role they played in people's day to day life and in helping them cope with various stresses brought about the pandemic. The results of the survey show that the use of green spaces among the sampled population of Vienna increased and the majority of respondents considered green space even more important during the pandemic than before. The survey has also conveyed people's preferences and satisfaction with urban green spaces as well as slight differences in use depending on people's age. During the pandemic, urban green spaces in Vienna have often been overcrowded and this has been the greatest source of dissatisfaction for the majority of survey respondents. Many people therefore sought refuge in the larger green spaces on the periphery of the city as these were perceived to offer more benefits as well as 'safety' in terms of the risks to contract the virus.

The conclusions of this research have implications for urban green spaces as a way to enhance urban resilience in the face of the ongoing and future pandemics, as well as other crises and uncertainties that are likely to occur in the future. It is certain that urban nature and green space have played an important role in people's life during the Covid-19 pandemic. Green areas have provided space for people to stay physically active at a time when they were confined to their homes most of the day. They have also allowed people to interact and maintain social contact – an extremely important factor in coping with isolation and loneliness during the pandemic – in a way that does not drive the virus infections further up. Moreover, people have found refuge and solace in urban nature which has helped them in coping with the stress and psychological burden of the pandemic. There is therefore no doubt that people's needs in a city, during a global pandemic and beyond, include having access to quality green spaces and to different types of green spaces throughout the city. The observed changes in the way people use green areas and other public spaces as well as the way that people moved around the city during a pandemic should be taken into account when planning for urban resilience and 'future-proofing' of our cities. Although this thesis did not address directly the environmental and sustainability benefits of planning for green spaces in a city, the advantages of them have been well-established before and are indirectly implied in this thesis.

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ANNEX I

Survey: urban green spaces in Vienna and the COVID-19 lockdown

The Covid-19 pandemic has changed the way we live, socialize and move around the city. Urban green areas have been one of the few public spaces that were accessible to people during the lockdown and many have found solace in nature around their neighborhoods and city. This questionnaire has been created to gather views and reflections on the use of green spaces in the city of Vienna during the Covid-19 pandemic.

The questionnaire is part of a Master thesis research by a student at the Department of Environmental Sciences and Policy at CEU. The questionnaire should take around X minutes to complete and it is entirely anonymous. Personal data is requested for statistical purposes only and will not be made in any way publicly available.

1. Do you live in Vienna?

- □ Yes
- □ No

2. Before the Covid-19 lockdown

This section refers to the period before the Covid-19 lockdown, when people could move freely anywhere.

2.1 Name of the green area that you used to visit most frequently.

••••

2.2 How far did you travel to reach the green area that you visited most frequently?

- \Box less than 500 m
- \Box between 500 m and 2 km
- \Box more than 2 km

2.3 How did you usually get to the green area?

- \Box On foot
- □ Bike
- □ Car
- □ Motorcycle
- □ Public transportation
- \Box Electric scooter
- □ Other

2.4 What kind of green area is it? (If you select Other, please, specify)

- \Box A tree-lined street
- \Box An urban park
- \Box River bank
- \Box Green area outside the city
- \Box Green area on the periphery of the city

□ Other _____

2.5 How frequently did you typically visit this green area?

- \Box Once a week
- \Box More than once a week
- \Box Several times a month
- \Box Once a month
- \Box Less than once a month

2.6 For which reason(s) did you visit the green area? (max. 3 answers; if you select Other, please specify)

- \Box Meeting people
- □ Physical exercise
- \Box Taking the kids outdoors
- □ Reading
- □ Observing nature
- \Box Taking the dog out
- □ Relaxing and stress-reduction
- Other_____

3. During the COVID-19 lockdown

3.1 If you go to a green area during the lockdown, what is the main reason? (max. 3 answers; if you select Other, please, specify)

- □ Meeting people
- □ Physical exercise
- \Box Taking the kids outdoor
- □ Reading
- □ Observing nature
- \Box Taking the dog out
- □ Relaxing and stress-reduction
- Other____

3.2 How frequently do you typically visit this green area (to the extent allowed) during the period of lockdown?

- \Box Once a week
- \Box More than once a week
- \Box Several times a month
- \Box Once a month
- $\hfill\square$ Less than once a month

3.3 Name of the green area that you visit most frequently

• • • • •

3.4 Is this the same area that you most frequently visited before the Covid-19 lockdown?

- □ Yes
- □ No
- 3.5 If not, why do you visit a different area?

•••

3.6 How far is the green area that you currently visit most often?

- \Box less than 500 m
- \Box between 500 m and 2 km
- \square more than 2 km
- 3.7 How do you reach the green area?
 - \Box On foot
 - □ Bike
 - □ Car
 - □ Motorcycle
 - □ Public transportation
 - \Box Electric scooter
 - Other_____

3.8 What kind of area is it? (If you select Other, please specify)

- □ A tree-lined street
- \Box An urban park
- \Box River banks
- \Box Green area outside the city
- \Box Green area on the periphery of the city
- Other____
- 3.9 During the lockdown do you prefer to visit green areas in the city or outside the city?
 - \Box In the city
 - $\hfill\square$ On the periphery of the city
 - $\hfill\square$ Outside the city

3.10 Why?

•••

- 3.11 During the Covid-19 pandemic, did your visitation to green areas decrease or increase?
 - □ Increased
 - □ Decreased
 - $\hfill\square$ It was the same as before the pandemic

3.12 Is access to green areas more important to you during the Covid-19 pandemic than before?

- \Box About the same
- \Box Yes, it is more important
3.13 How much do you agree with the following statements? (1 not at all -5 very much)

- □ Visiting green areas improved my physical health during the lockdown
- □ Visiting green areas improved my mental health and well-being during the lockdown
- □ Green areas improve public health
- □ Frequenting green areas during the pandemic makes people less lonely and isolated
- □ Green areas are important for meeting people while having to socially distance

4. Satisfaction with green areas

4.1 To what extent are you satisfied with the following aspects of green areas that you frequented during the Covid-19 lockdown?

	Not at all	Little	Rather	A lot	No opinion
Presence of recreational facilities (playground/exercise equipment)					
Quiet/freedom from noise					
Aesthetic appearance					
Natural value					
Presence of wild animals					
Variety of vegetation					
Equipment for relaxing (e.g. picnic tables/benches)					

4.2 What would you improve in the green area that you frequented? (max. 3 answers; if you select Other, please specify)

- \Box Elements for relaxation (e.g. benches and tables)
- □ Natural value (e.g. more wooded areas etc.)
- □ Visibility with open areas (e.g. lawn)
- □ Areas for sports and recreation (e.g. playground/exercise equipment)
- \Box Level of noise pollution
- □ Microclimate (e.g. shaded areas)
- \Box Aesthetic appearance
- □ Waste collection/cleanliness
- □ Number of visitors
- Other____

4.3 Is there a green area closer to where you live but that you did not frequent during the lockdown?

- \Box Yes, there is
- \Box No, there isn't

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4.4 If yes, why?
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4.5 Do you think Vienna has enough green areas in the city?

- □ Yes
- $\hfill\square$ There could be more

5. Personal reflections

5.1 Please share a thought (or suggestions) regarding urban green spaces and their role in people's lives during the Covid-19 pandemic.

•••

5.2. Comments

•••

6. Personal details (anonymous)

The questionnaire is anonymous and this information will be used only to understand the composition of sample.

6.1 Gender

- □ Male
- □ Female
- □ Other

6.2 Age

- \Box Less than 20 years old
- □ Between 20 and 29
- \Box Between 30 and 39
- \Box Between 40 and 49
- \Box Between 50 and 59
- □ Between 60 and 69
- □ Between 70 and 79
- \Box Above 80

6.3 Education

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- □ High school diploma
- □ Apprenticeship
- □ University/college degree
- □ Post-graduate degree

6.4 Employment

- □ Employee (public / private)
- □ Free-lance
- □ Retired
- □ Unemployed
- □ Student
- □ Stay-at-home parent
- Other_____