Health and the Urban Environment of the Twin Cities of Ramallah and Albireh in the Occupied Palestinian Territory

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Abstract

Background: Features of the urban environment can support human health as well as harm it. Evidence has accumulated for the links between different place-based characteristics and physical and mental health. However, this evidence stems primarily from highly developed countries. The extent to which it is generalisable to other locations, such as the Middle Eastern Arab region, which has unique political, socio-cultural, and climatic environments, is not clear.

Aims and setting: This thesis aims to investigate health in relation to the urban environment in the twin cities of Ramallah and Albireh in the occupied Palestinian territory. Specifically, it will examine the associations between the risk of chronic illness and: a) politically created area disadvantage (refugee camps and 'Area C'); b) urban green space. It will also explore the interaction between these area-level features and age, sex, and household assets in their association with chronic illness.

Methods: Area-level variables were linked with individual respondents to the 2017 census using a Geographic Information System. The analytical sample was 54693 individuals living in 228 residential areas. The outcome variable was the presence/absence of chronic illness. The area-level variables were the politically created disadvantage indicated by Refugee camps and political land classification 'Area C' (controlled by Israel); the proportion of mixed trees, crop trees and open space with little/no vegetation; Individual-level variables included twelve demographic and socioeconomic characteristics. Multi-level logistic regression models examined associations and interactions between individual and area-level variables and the probability of chronic illness risk.

Results: On the political dimension, living in the context of a refugee camp was associated with greater odds of chronic illness (OR 1.91 CI [1.17-3.09]). This association was attenuated and rendered non-significant when adjusting for green space. The proportions of 'mixed' trees in residential areas had an independent inverse association with chronic illness (OR 0.96 CI [0.95-0.97]). There was no/weak evidence for an association between the context of 'Area C' and the proportion of crop trees and open space with the risk of chronic illness. A statistically significant interaction was found between sex and living in refugee camps. Females living outside refugee camps have a significantly lower risk of chronic illness compared to males but not for those living inside refugee camps; females inside refugee camps had a higher risk of chronic illness compared to males (though not a significant difference). There was no/weak evidence for interactions between the other area characteristics and age, sex, and household assets.

Conclusion: This is the first study in the Palestinian context, and among the few from the Arab World, to investigate links between the urban environment and health. As expected, living in the disadvantaged context of refugee camps is associated with a higher likelihood of chronic illness. Not all greenspace types were associated with improved health outcomes, but mixed trees were, and the green environment appeared implicated in the association between refugee camps and poor health. These results from a Middle Eastern Arab setting add to the evidence, largely from Western countries, that mixed trees in urban environments benefit health. Researchers and policymakers interested in reducing health inequalities should give more attention to refugee camps and green typologies, especially to females living in the disadvantaged contexts of refugee camps who may gain greater benefits. Research with a broader scope is needed to investigate the impact of political land classification on health.

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List of Acronyms

ADI	Area Deprivation Index
ANERA	American Near East Refugee Aid
ARIJ	Applied Research Institute Jerusalem
BMI	Body Mass Index
BCE	Before Common Era
CI	Confidence interval
DALY	Disability Adjusted Life Years
DHS	Demographic and Health Survey
ESRI	Environmental Systems Research Institute
EMRO	Eastern Mediterranean Region
GP	General Practitioner
GHQ	General Health Questionnaire
GIS	Geographic Information System
GPS	Geographic Positioning System
IBSSS	International Bibliography of the Social Sciences
ICC	Interclass correlation coefficient
IDRC	International Dispute Resolution Centre
IHME	Institute of Health Metrics and Evaluation
Km	Kilometre
MOR	Median Odds Ratio
MeSH	Medical Subject Heading
MoLG	Ministry of Local Government
NDVI	Normalised Difference Vegetation Index
oPt	occupied Palestinian territory
OR	Odds Ratio
PA	Palestinian Authority
PCA	Principal Component Analysis
PCBS	Palestinian Central Bureau of Statistics
PEO	Population Exposure Outcome
PLO	Palestinian Liberation Organisation
UK	United Kingdom

UN	United Nations
UNRWA	United Nations Relief and Works Agency
UNEP	United Nations Environment Programme
USA	United States of America
VPC	Variance Partition Coefficient
VIF	Variance Inflation Factor
WHO	World Health Organisation

Publications and Conference Presentations

The research in this thesis was disseminated through the following publication and conference presentations:

Publications

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Author's declaration

Ahmad M. Alkhatib

I certify that the thesis presented here for examination for the PhD degree at the University of Glasgow is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it) and that the thesis has not been edited by a third party beyond what is permitted by the University's PGR Code of Practice.

The copyright of this thesis rests with the author. No quotation from it is permitted without full acknowledgement. I declare that the thesis does not include work forming part of a thesis presented successfully for another degree. I declare that this thesis has been produced in accordance with the University of Glasgow's Code of Good Practice in Research. I acknowledge that if any issues are raised regarding good research practice based on the review of the thesis, the examination may be postponed pending the outcome of any investigation of the issues.

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Chapter one: Introduction

1.1 Background

The potential for urban environments to support human health, as well as to harm it, is well recognised (Galea *et al.*, 2005; Freudenberg, Galea and Vlahov, 2006; Gruebner *et al.*, 2017; Richardson *et al.*, 2017; Frank *et al.*, 2019; McGowan *et al.*, 2021). Studies investigating places and health have grown substantially in recent decades. Searching for the terms "places and health" in the PubMed database showed 2297 articles published in 2000 compared to 15252 in 2020. These studies developed our understanding of the role of place-based attributes as determinants of health and health inequalities (Arcaya *et al.*, 2016; Duncan and Kawachi, 2018; Green *et al.*, 2019).

However, the mounting evidence linking population health outcomes with urban environmental features is not sufficiently representative worldwide. Whilst the influence of well-developed and slowly changing urban forms have been explored; there is substantially less research on rapidly growing, less-developed urban areas (El-Zein *et al.*, 2014; Giles-Corti *et al.*, 2016; Alhuwail *et al.*, 2020).

Less developed urban settings, such as those in the Arab World[1], are facing considerable social and environmental challenges and increasing trends of non-communicable diseases (Abdul Rahim *et al.*, 2014; El-Zein *et al.*, 2014; Mokdad *et al.*, 2014; van den Bosch and Ode Sang, 2017). Economically developing countries are projected to witness significant urban population growth and exacerbation of challenges, with a substantial need for research to inform the local and regional planning and public health policies (United Nations, 2018).

The evidence predominantly generated in developed countries cannot be generalisable and translated to less developed ones; these contexts are

[1] The Arab World includes 22 Arab speaking countries in the Middle East and North Africa that are members of the Arab League

significantly different. For example, countries are distinct in multiple domains, including political economy, culture, history, geography, climate, and political conditions. These broader systems are fundamental in shaping urban environments' forms, structures, and functions. They influence how cities are designed, how resources and services are distributed, how people experience, value, and use their cities and the features of their local environment—ultimately impacting how urban features have an effect on population health (McMichael, 2000; Ottersen *et al.*, 2014; Markevych *et al.*, 2017).

My research aims to contribute to the evidence on the urban environment and health of an understudied geographical region. This will be done by investigating the urban environment and health in the twin cities of Ramallah and Albireh in the occupied Palestinian territory (oPt). More specifically, the research will focus on two aspects of the residential areas in a Palestinian urban setting: (1) politically created disadvantages and (2) green space. It will assess the relationship between these area-level features and a health outcome and how they interact with the characteristics of the residents.

In this introductory chapter, I will first provide background about the relationship between places, population health and the social-ecological model of health. Then, I will focus on the context of residential areas and the 'area effect' on health. In the following section, I will discuss why I selected the twin cities of Ramallah and Albireh and the area-level characteristics of this research. The chapter ends by setting out the thesis objectives and outline.

1.1.1 Health and places

It is well-known that health and disease outcomes are geographically patterned. People living in certain places might have better physical and mental health, fewer diseases, and live longer than people living in other places. Investigations worldwide showed that health indicators aggregated by areas differ at all geographical scales; between regions, countries, cities, communities and neighbourhoods (Jones and Moon, 1993; Macintyre and Ellaway, 2009; Pearce, Mitchell and Shortt, 2015; Bambra, 2016; Richardson *et al.*, 2017).

Population health indicators show large differences between countries (Marmot, 2015; Abbafati *et al.*, 2020; Liou *et al.*, 2020). For example, life expectancy, the most frequently used health status indicator, was 50 years in some African countries in 2019, which compares poorly to countries such as France, Canada, and Japan, where the life expectancy reached more than 86 years (Figure 1-1). Such unequal health outcomes were also seen within the same region. For example, looking at health indicators in the oPt compared to the state of Israel in 2018: life expectancy was ten years less in the oPt; the infant mortality rate was about six times more in the oPt; and the top nine causes of death were significantly higher in the oPt compared to Israel (WHO. EMRO, 2018; Rosenthal, 2021).

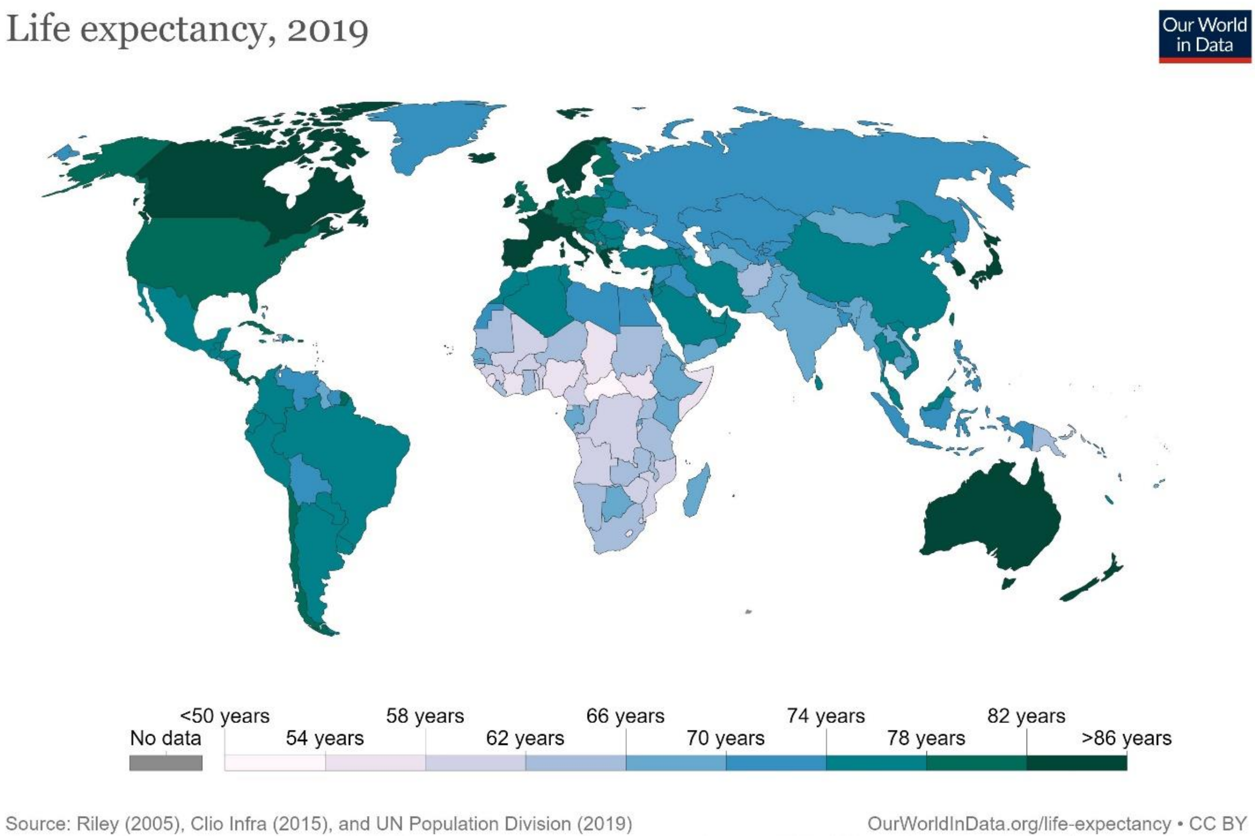

Figure 1-1: Life expectancy at birth: a world map in 2019 obtained with permission from Roser Max, Ortiz-Ospina Esteban (2019)

Geographical differences in health within countries were also well documented worldwide. For example, investigations dating back to the 1970s in Britain revealed stark geographical differences in the health between the north and the south regions and between localities and communities (Curtis & Jones, 1998;

Duncan, Jones, & Moon, 1998). For example, in the Glasgow city region in 2019, male residents of Glasgow were expected to live a healthy life 15 years less than those living in the neighbouring locality of East Dunbartonshire (Whyte, Young and Timpson, 2021). At smaller scales between neighbourhoods within some localities, the variations in health were even more pronounced (Pearce, Mitchell and Shortt, 2015; Bambra, 2016; McGowan *et al.*, 2021; Whyte, Young and Timpson, 2021). So, why do health outcomes differ between places?

Health geographers attributed these geographical variations in health outcomes to compositional and contextual effects. The *compositional explanation* implies that health differs between places because of the distribution of types of individuals living there(Jones and Moon, 1993; Duncan, Jones and Moon, 1998). There is solid and well-established evidence linking different health outcomes to biological factors (e.g., genetic), demographic characteristics (e.g., age, sex, ethnicity), socioeconomic status (e.g., education, employment, income) and to behavioural or lifestyle factors (e.g., smoking, diet, alcohol, physical activity) (Scarborough *et al.*, 2011; Kohl *et al.*, 2012; Holman *et al.*, 2020). For example, an area with a high proportion of individuals with low socioeconomic status or health-damaging behaviours is expected to have lower self-rated health and higher mortality than an area with low ratios of such individuals.

The *contextual explanation* refers to the geographical considerations and the characteristics embedded in the physical, social, economic, political and cultural structures of places in which people are born, grow, live, work and age (Commission on Social Determinants of Health, 2008; Pearce, Mitchell and Shortt, 2015). Thus, scholars argued that health outcomes vary from place to place because of a combination of compositional and contextual factors. For example, certain areas may exhibit high rates of heart disease because many people living in these areas have personal attributes and habits that make them prone to heart diseases and because of a broader environmental context that is damaging or not supportive to health. The developments in public health and social sciences and the social-ecological model of health influenced this argument, discussed in the following section.

1.1.2 The social-ecological model of health

The term ecology originated from the biological sciences referring to the interconnection between organisms and their surroundings, and was usually used interchangeably with the terms 'context' and 'environment'. In the middle of the 19th century, Rudolf Virchow, the founder of biomedicine, argued that medicine is a social science as much as biological science and emphasised the importance of social and environmental factors in shaping population health (Lange, 2021).

Health and social sciences researchers have since adopted the term ecology, referring to people's living conditions and environmental interactions (Sallis, Owen and Fisher, 2008). Geoffrey Rose, a prominent epidemiologist credited with transforming modern preventative public health thinking, referred to these broader characteristics as "the causes of the causes" of diseases (Schwartz and Diez-Roux, 2001), given their central role in shaping the health and well-being of the people both in the short and long term.

The social-ecological model of health has early roots in history and was one of the most influential frameworks supporting the paradigm shift from focusing exclusively on individuals to a broader social and ecological view of health and the upstream preventive public health measures. Its developments and applications in modern health sciences facilitated a holistic understanding of the determinants of health by integrating various factors at multiple levels of organisation (Krieger, 2001; Sallis, Owen and Fisher, 2008; Edberg, 2015). It placed the individuals and their environment equally essential to promote the population's health.

An attribute of the social-ecological model is its adaptability to various phenomena and outcomes, and the hierarchies can be illustrated differently. There are several developments and versions of the social-ecological model. One of the most common ones is Dahlgren & Whitehead's (1991) framework for the determinants of health or "The Rainbow Model", which was influenced by the earlier Bronfenbrenner *ecological systems theory* of child development (Bronfenbrenner, 1979).

The Rainbow Model conceptualised the determinants of health and organised them into four ecological layers: first, the microsystem or lifestyle factors, such as daily activities and habits; second, the mesosystem or interpersonal factors, such as family, peers, and social networks; third, the exosystem or living and working conditions, including neighbourhood or community, school, and work; Finally, the macrosystem consists of the macro socioeconomic, sociocultural, and environmental domains (Dahlgren and Whitehead, 2021).

Inspired by the principles of sustainable development, Barton & Grant (2006) further expanded and amended the Rainbow model to create 'The Health Map' that incorporated aspects of the human settlements (Figure 1-2). It reflected a human habitat by nesting individuals into seven ecological levels of social and environmental influences. The depiction of the different social, economic and physical environmental factors surrounding individuals added more details to the theoretical thinking.

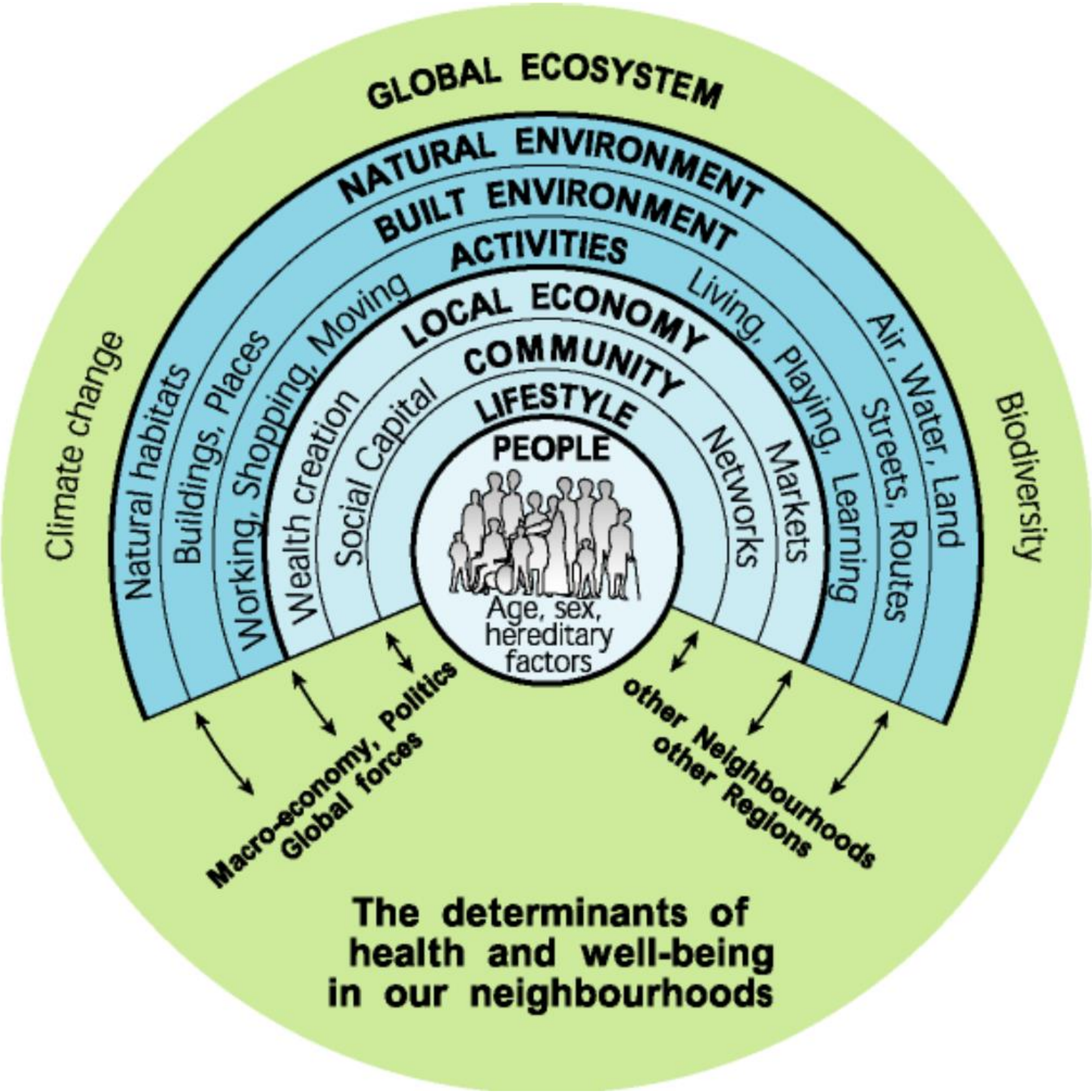

Figure 1-2: The Health Map, obtained from Barton & Grant (2006), with permission from SAGE publication

A wide range of biological, chemical, physical, social, economic, commercial, political, and cultural factors influence health and are interrelated and manifest at multiple levels. The social-ecological model is a helpful representation of these factors and hierarchies. It acknowledges that going higher up the scales implies broader effects, and each component impacts individuals and the whole system in reciprocal relationships. In the following section, I will focus on the areas of residence, which is the ecological unit of analysis of this research.

1.2 The context of the area of residence and health

As I discussed in the previous section, health is attached to everyday living conditions "in which people are born, grow, live, work and age"(Commission on Social Determinants of Health, 2008). Arguably residential areas (or neighbourhoods) are one of the essential contexts where people spend the substantial bulk of their lives.

Research on the effects of the context of residential areas on health has exploded in the last three decades, termed the ‘area-effect’ or the ‘neighbourhood effect’ (Diez Roux & Mair, 2010; Duncan & Kawachi, 2018). Scholars interested in the area-effect built on the social-ecological model of health (discussed above) and proposed multiple theories and concepts to help understand how places shape the health of individuals.

Initially, researchers sought to estimate the ‘area effect’ on health through the socioeconomic profile, differentiating between disadvantaged and advantaged areas. Another recent approach was investigating specific aspects of residential areas' social and physical environment. In this section, first, I will introduce the socioeconomic environment, how it was measured, and some of its limitations. Then I will discuss the social and physical environments and their relationship with the socioeconomic environment.

1.2.1 The socioeconomic environment

Research looking at the ’area effect’ on health is dominated by studies focusing on the socioeconomic environment as an area-level predictor (Arcaya *et al.*, 2016). A key work was the Black Report in the UK in 1980, which the government commissioned to explore why health outcomes differ across socioeconomic groups (DHSS, 1980).

There are several measures for the socioeconomic environment; a common measure is to use the aggregated characteristics of people living in these areas, such as the percentage of unemployed people or people with low education. These measures can also be combined in indices, referred to as indices of deprivation, such as the widely used Area Deprivation Index (ADI), Townsend Index and Carstairs & Morris Index (Pasetto, Sampaolo and Pirastu, 2010; Kind and Buckingham, 2018). For example, the Townsend index of deprivation provides a single value for each electoral ward[2] in the UK, which includes the percentage of households with car access, rate of homeownership, percentage of unemployed individuals and overcrowding (Stafford and Marmot, 2003).

The concept of area socioeconomic disadvantage or deprivation is multi-dimensional, referring to the deteriorated living conditions, poor material circumstances and the reduced capacity of the individuals to participate in broader social life (Cockerham, Hamby and Oates, 2017; Norris, 2017). Townsend distinguished the concept of deprivation from poverty as related to the underprivileged *environmental* circumstances of individuals. He defined it as "a state of observable and demonstrable disadvantage relative to the local community or the wider society or nation to which an individual, family or group belongs" (Townsend, 1987, page 25).

Different area-level socioeconomic measures were linked to various health outcomes, discussed further in chapter three. It is likely that the differences in the level of deprivation between areas create disparities in health and well-being outcomes and contribute to inequalities in health. However, scholars called for thinking beyond the socioeconomic environment for several reasons. Mainly, these area-based measures of socioeconomic status were criticised because they rely only on the characteristics of the residents as proxies for the area effect, which may not reflect the social and environmental aspects embedded within places but rather the impact that individuals make on places (Macintyre, 1997; Mitchell *et al.*, 2000).

Furthermore, the aggregated socioeconomic measures or indices do not indicate why low scores are harmful to health and do not explicitly identify an area-level

[2] "Electoral wards have an average population of about 5500"

factor that can be linked to health as a potential target by specific environmental policy or intervention (Diez Roux & Mair, 2010; Duncan & Kawachi, 2018). They highlighted geographical inequalities in health, but they only partially answered the question of why health varies between places. Areas with the same socio-economic conditions might still differ in the social and physical factors. This might not be related to the area's socioeconomic environment but could be a result of other external forces (Tunstall *et al.*, 2007). For example, life in a deprived area with certain vital services might be expected to be less harmful than life in an area with the same level of deprivation but without these services. Furthermore, the social and physical factors might have different pathways and importance to different people's health outcomes. For example, Diez-Roux et al. (1997), found that living in deprived areas in the United States of America (USA) is associated with poorer health outcomes, above and beyond individual-level factors. However, this association was not significant for all men. And in some localities, area disadvantage was associated with a lower risk of disease. This might be explained by the presence of other contextual factors in the social and physical environment that benefit health, thus mitigating the risk from socio-economic disadvantage. There are further conceptual and methodological problems in this line of research; these will be discussed in detail in the following chapter.

Nevertheless, these aggregated measures are valuable as they capture broader ecological processes and mechanisms that influence the health of individuals other than from individual-level operations (Curtis and Jones, 1998). Additionally, these area-based measures are practical alternatives when individual-level data are not available or confidential.

1.2.2 The social and the physical environment

The interest shifted in the scientific literature toward more specific environmental attributes of places and precise area-based measurements to investigate the ‘true’ contextual qualities of places that may impact health (Diez Roux and Mair, 2010; Arcaya *et al.*, 2016). This was reinforced by the increasing availability and quality of high-precision health measures and data, spatial datasets and geographic information systems data (GIS) that allowed the linking of data about individuals via their locations (Diez Roux and Mair, 2010; Kestens *et al.*, 2017). In parallel to the advancements in analysis, statistical tools and processing power, all of which enabled the use and analysis of such linked data. These developments facilitated a much better understanding of health and place relationships. These specific environmental attributes are often differentiated into two distinct yet interrelated and broad themes, the social and the physical environments, discussed in the following section (Curtis and Jones, 1998; Diez Roux and Mair, 2010).

Most theories concerning the ‘area-effect’ on health suggest that the social and physical environment characteristics mediate the association between area socioeconomic disadvantage and health outcomes (Diez Roux and Mair, 2010; Pearce *et al.*, 2010; Pearce, Mitchell and Shortt, 2015; Duncan, Regan and Chaix, 2018). With the increase in the area-level socioeconomic disadvantage, the social and physical environments deteriorate, damaging health through harmful exposures and stressors, reducing opportunities for healthy living, and encouraging unhealthy behaviours (O'Brien, Farrell, & Welsh, 2019; Pearce et al., 2010). Thus, differential exposure to the physical and social environment characteristics can promote or damage health and drive spatial inequalities in health (Pearce, Richardson, Mitchell, & Shortt, 2010).

1.2.2.1 The social environment

Aspects of the social environment usually refer to the characteristics and the nature of the local social functioning, organisation, networks, and connections, which operate through places and influence health and behaviours. Some features of the social environment might benefit people, such as positive peer influence, social cooperation, social capital[3], social support, trust, and safety. For example, areas with high levels of trust and social participation tend to have better health status, regardless of these areas' demographic and socioeconomic composition (Lochner *et al.*, 2003). Other social features of places might harm people, such as

[3] Social capital refers to “the features of social organisation such as trust, norms, and networks that can improve the efficiency of society by facilitating coordinated actions” (Putnam, 1993, page 167)

negative peer influence, high crime levels, violence, and discrimination (Cattell, 2001; Galster, 2012; Sharp and Kimbro, 2021). Other social aspects of places might influence health, for example, area reputation and history, which can stem from various social, economic, political, and environmental reasons. These features might stigmatise or promote certain places, thus determining public investment and how the residents experience these places and are attached to them.

1.2.2.2 The physical environment

The physical environment includes traditional public health concerns such as waste facilities, contamination of land and water, air pollution, and road safety. With the increasing urbanisation parallel to the rising trend of non-communicable diseases and their risk factors, sizable evidence suggests a significant influence of urban design and planning on population health outcomes. These include but are not limited to the buildings and streets designs, the quality of pavements, land use, urban green space, transport and sanitation systems (Corburn, 2004; Galea *et al.*, 2005; Berke and Vernez-Moudon, 2014; Gong *et al.*, 2016; Gruebner *et al.*, 2017; Schulz, Romppel and Grande, 2018; Felappi *et al.*, 2020).

1.2.2.3 The relationship between the physical and social environment with the socioeconomic environment

The deteriorated conditions of the physical environment (referred to as “physical decay”) may reflect the state of the area's socioeconomic disadvantage. They influence individuals through aspects such as higher exposure to environmental pollutants and also via psychosocial factors, such as stress and a reduced sense of efficacy among residents (Galster, 2012). For example, a study in 439 German counties found that perceived air pollution and noise explained the association between area-level deprivation and subjective physical health (measured by the health-related quality of life SF-12 questionnaire) (Voigtländer, Berger and Razum, 2010).

Disadvantaged areas are also characterised by a higher likelihood of poor economic opportunities, public and private services, health care services, transport, amenities and institutional resources, both in quantity and quality, that do not meet the health needs of the residents (Davey Smith *et al.*, 1998; Hastings, 2009). These are also referred to as 'opportunity structures' that might have detrimental consequences on living conditions and healthy behaviours (Macintyre, Ellaway, & Cummins, 2002). Disadvantaged areas are more likely to have food and grocery outlets that are not sufficiently supportive of a healthy diet or act as proximal exposures to health-damaging products such as tobacco, alcohol and junk food (Cummins, McKay, & MacIntyre, 2005; Day & Pearce, 2011; Macdonald, Olsen, Shortt, & Ellaway, 2018). For example, in a longitudinal cohort study in England, the area-level socioeconomic disadvantage was positively associated with a high density of fast-food outlets, and residents were more likely to be overweight than those living in the least disadvantaged areas (Green *et al.*, 2021).

The unequal distribution of health-promoting features in the physical environment plays an integral part in creating inequality in health. Studies showed that people living in disadvantaged areas have fewer green spaces than in well-off areas (Mitchell and Popham, 2008; Pearce *et al.*, 2010). They are less likely to participate in outdoor physical and recreational activities related to less access to safe and maintained public parks (Lee and Maheswaran, 2011). Many other aspects characterise disadvantaged areas, such as fewer educational resources or schools offering lower education quality, or a lack of recreation and social interaction (Voigtländer, Berger and Razum, 2010). All these aspects are important for good living conditions.

The more recent measures of deprivation combined multiple aspects of people and their environment. Indexes of Multiple Deprivation (with different versions prepared by the constituent countries of the UK), each used information about individuals and area-level features, such as rates of crime, barriers to housing and services, and the quality of the local living environment, such as air quality and traffic accidents (Pearce *et al.*, 2010). Scholars argued that these newer measures were better than the earlier ones because they now include environmental attributes and have a smaller spatial scale, containing more homogeneous people in terms of their characteristics and health (Curtis and Jones, 1998). However, these measures have also been criticised because contextual effects operate at different spatial scales. Larger spatial scales are also important; the city level, region, or nation, for example, can all have an influence, for example, in terms of the labour market. Furthermore, these measures still failed to fully capture the complexity and multi-dimensionality of the effects of contexts on health which include several intertwined features related or not to socioeconomic disadvantage and should be included within analytical models of health (Walsh *et al.*, 2017).

In sum, area socioeconomic disadvantage or deprivation can be measured in many ways, either from a single variable or a composite score of multiple variables. The aim and assumption of these measures are that they capture the state of living conditions, population, accessibility, and opportunities in places. Socioeconomically disadvantaged areas are characterised by fewer opportunities via the lack of resources and amenities and deteriorated social and physical environments.

Area disadvantage operates on individual health outcomes via various intertwined channels and is confounded by external factors. In the following chapter, I will provide a further theoretical discussion about the ‘area effect’, methodological considerations and macro-level and relational mechanisms in how places influence health. The following section presents the reasons for selecting the study area and the contextual factors of interest in this thesis.

1.3 The study area and the area-level features of interest

There are three main reasons behind selecting the twin cities of Ramallah and Albireh in the oPt as a study area for this thesis. First, their location within the oPt makes them ideal for assessing relatively well-established urban environmental influences on health but in an understudied setting which has novel political influences specific to the region. Second, the twin cities capture the range of issues that the oPt face; hence, they are reasonably representative of cities in the oPt. Third, the twin cities combine features of both local and regional urban contexts. The urban expansion, modernity, and development they witnessed resemble other cities in the Arab region but with a more specific political environment (Taraki, 2008; Aruri, 2015). Overall, the study site enables me to investigate relationships between the urban environment and health identified within the western metropolitan areas, in a part of the world experiencing rapid urbanisation and with a unique social, political, and cultural background.

In the twin cities of Ramallah and Albireh, like other cities in the oPt, the political landscape is unique, related to historical events and the Israeli military occupation (discussed in chapter four). These political conditions significantly impact multiple aspects of life in the oPt. One of these impacts is on place, and, in this thesis, the interest is on the link between area disadvantages created by these conditions and health. Specifically, the interest is in two political features that disadvantage areas in the twin cities of Ramallah and Albireh. Those are refugee camps and political land classification (Area C). In chapter four, I will describe these contexts, how they were created, and the current political environment in the oPt in more detail.

The component of the urban physical environment of interest in this thesis is urban green space. The interest in green space arises from it being an important, perhaps even essential, element of healthy and sustainable urban infrastructure (Haaland and van den Bosch, 2015; UN-Habitat, 2020). It could be argued that humans have an intrinsic evolutionary connection and attachment to nature (Newell, 1997). However, contact with nature was reduced in many places worldwide, including the Arab World, due to increasing pressures from extensive urbanisation and cities' densification.

There is a large body of evidence that emphasises the role of urban green space in supporting individuals' health outcomes and healthy behaviours (discussed further in chapter three) (Mitchell, Astell-Burt and Richardson, 2011; Cleland *et al.*, 2019; Hu and Li, 2020; Salgado *et al.*, 2020; Zhang, Tan and Richards, 2021). Furthermore, green space plays a vital role in providing ecosystem services locally and globally, which eventually impact population health on a larger scale (Haaland

and van den Bosch, 2015; Zupancic, Westmacott and Bulthuis, 2015; Salgado *et al.*, 2020). For example, it helps maintain healthy and balanced natural biodiversity by providing habitats for various life forms (Wood *et al.*, 2018). It also plays an essential role in reducing the local and global temperatures and urban heat and mitigating climate change (Markevych *et al.*, 2017; Hu and Li, 2020; Watts *et al.*, 2021).

However, as I discussed earlier, one of the main limitations in the evidence linking urban green space and health is the lack of studies from less developed countries, especially in the Arab World (Rojas-Rueda *et al.*, 2019; Shuvo *et al.*, 2020). This research will contribute to the international evidence by addressing this gap.

1.4 Thesis objectives and outline

This thesis investigates the relationship between health and features of residential areas in the twin cities of Ramallah and Albireh in the occupied Palestinian territory. The main objectives were:

- To investigate the variation in health between residential areas in the twin cities.

- To examine the relationship between the politically created area disadvantage and residential green space with health.

- To examine the interaction between the area-level and individual-level characteristics in their association with health.

This chapter started with the contribution of this research, filling the gap in the evidence about the urban environment and health relationships. I presented a theoretical background on the relationship between health and places and the impact of different features of residential areas that may impact health. Finally, I set out the reasons behind choosing the study area and the area-level characteristics of interest in this research.

In chapter two, I will expand the theoretical discussion on the relationship between health and places to better understand this relationship. I will discuss the macro-level factors and the interaction between area-level features and personal characteristics. I will also discuss methodological considerations pertaining to analysing how the characteristics of places might affect health.

In chapter three, I will put the objectives of this thesis in the context of international empirical evidence. First, I will describe the material I used in the literature review and the search methodology. Second, I will focus on research about the relationship between health outcomes and area-level disadvantages, including politically created disadvantages. Third, I will review the evidence on the benefits of urban green space to population health. Finally, I review research on the interaction between area disadvantage and urban green space with personal characteristics.

Chapter four will provide an overview of the context of the study. It will start with an overview of significant historical and political events that shaped the occupied Palestinian territory and briefly describe the current conditions—then focus on the twin cities of Ramallah and Albireh and information relevant to this thesis.

Chapter five will present the data that I obtained and used to reach the objectives of this thesis. It will describe the mechanism of handling and preparing the data at the individual and area levels and present the final data set used in the analysis.

Chapter six will start with the specific research questions of this thesis and detail the statistical methods and their different constituents used to answer these questions.

Chapter seven will present the results of the analysis and their interpretation.

Finally, chapter eight will discuss the findings related to each research question in the context of international evidence. It will present the strengths and limitations of the analysis, the implications and the recommendations based on the findings.

Chapter two: Theoretical and methodological reflections on the connection between places and health

In the previous chapter, I discussed that variations in health and well-being between individuals and places are attributed to a combination of individual and environmental factors. I described the social-ecological model of health and that place-based factors are often classified into socioeconomic, social, and physical characteristics. However, the relationship between people and places is much more complex and investigating place-based determinants of health is challenging. This perhaps explains why, despite advancements in methodological complexity and a growing number of studies specifically designed to understand the place-based effects on health, there is no single dominant and comprehensive model for this relationship (Duncan & Kawachi, 2018). After all, what aspects influence different health outcomes, how they interact and for all settings is challenging to integrate into one conceptual framework.

In this chapter, I will build on the theoretical reasoning presented in the previous chapter and discuss selected theories and ideas that addressed this complexity, helped understand the link between places and health, and are most relevant to this thesis's objectives and analysis. First, I will discuss the concept of separating the contextual effects on health from the compositional using the multi-level methods, their convenience and their limitation. Second, I discuss critical theories that address the connection between people and places, connect it with macro-level processes that shape them, and address individual-level processes that underlie the differential impact of places and people.

2.1 Separating the contextual from the compositional explanations and multi-level methods

Researchers interested in the relationship between places and health often conceptualise it as operating at multiple levels, commonly two; the individual and the area level. They use multi-level methods to analyse their data, where the study design allows. This enables examining the relative importance of areas and the association between features of areas and health outcomes while simultaneously considering the population's composition (Duncan, Jones and Moon, 1998). Multi-level methods allow for conclusions that places where people live hold features that influence health independently or above and beyond their residents' characteristics (Macintyre, Ellaway, & Cummins, 2002).

However, the very idea of structuring places and people at two levels and separating factors affecting health into ‘context’ and ‘composition’ is simultaneously valuable and problematic (Kearns and Moon, 2002). Many scholars have criticized the ‘false’ dualism of context and composition, stating that these factors are mutually exclusive (Mitchell, 2001; Macintyre, Ellaway and Cummins, 2002). They argued that it is an oversimplification of a much more complex phenomenon. Theoretically and conceptually, it isn't easy to clearly distinguish between the contextual and the compositional effects (Frohlich, Corin, & Potvin, 2001; Macintyre et al., 2002).

On the one hand, places shape people’s living conditions, life chances, attitudes, and identities, but on the other hand, people are active in creating, maintaining, and changing places. People and places are highly interrelated and mutually reinforcing. For example, the individuals’ health-related behaviours (such as diet, physical activity, and others) are subject to the available resources in the local areas. At the same time, the resources in the local areas are subject to the resident's needs, demands and preferences and economic conditions. The relationship between people and places is thus dynamic and mutually constructive. Separating the ‘area’ and ‘individual’ effects ignores this dynamic relationship.

Oakes argued that the area effects are ‘endogenous’ or dependent on the compositional factors-especially when the area effects are captured by proxy socioeconomic measures derived from aggregated individual-level data. Oakes claimed that accounting for the (confounding) individual characteristics will reduce the variation in the outcome of interest between areas to close to zero. For example, very few rich people will live in poor neighbourhoods when controlling for individuals' socioeconomic status. A low number of people in the social strata will not effectively account for confounding (Oakes, 2004).

Another issue is the possibility that individual-level factors such as socioeconomic position might not be a confounder but a mediator of area-level socio-economic conditions (Diez Roux and Mair, 2010). They could lie on the pathway between area-level factors and health outcomes. These situations may be more apparent when looking at larger geographical units; for example, individuals’ unemployment might be related to the unavailability of economic opportunities in their locality or district. The mechanisms by which poorer people are spatially organised in risky environments further create and facilitate social differences (Mitchell, 2001).

However, careful consideration of the conceptual model, the confounding and mediating factors, the degree of social segregation and clustering, and the nature of the area-level variable of interest might help alleviate some of these issues and reduce the biases in studies. The within and between area variation can be tested through different models to assess how the various sources of variation explain the outcome of interest (Larsen and Merlo, 2005). This variation, and what remains after controlling for individual-level factors, can be valuable indicators of an ‘area effect’ so long as we remain mindful of the limitations of the data and method. The between-area variation also provides helpful information about the relevance of the boundaries of the areas for health disparities (Austin & Merlo, 2017; Merlo, Ohlsson, Lynch, Chaix, & Subramanian, 2009).

Some aspects of the social and physical environments are ‘true’ contextual effects and not derived from individuals' characteristics, such as political forces and urban green space. These are ‘imposed’ on individuals and out of their control. The unequal distribution of these ‘exogenous’ environmental features might be related to the health of the individuals, independent of their personal attributes. Appropriate research questions that seek to identify and test associations with individual-level outcomes can be informative and fundamental. Such research might pave the way for further studies with more rigorous confirmation of the causal effect (Diez Roux and Mair, 2010).

I will use the multi-level approach in this thesis. Further discussion about the multi-level models and their benefits will be discussed in chapter five. Other weaknesses and limitations specific to the analysis in this thesis will be discussed in chapter eight.

2.2 Other aspects of the relationship between places and health

Other aspects of the relationship between places and health further complicate the matter. One is that both people and places are subject to forces and contexts at the macro-level, such as the regional economic, political, and cultural environment, and these can contribute to the spatial distribution of health and diseases. Two is that the influence of the context is not universal and might differ between individuals and subgroups.

In this thesis, these aspects will be approached within the capacity of the available data and multi-level modelling. It will examine the association between macro-level political features and individual-level outcomes and the interaction between the characteristics of areas and people in their relationship with health. The following two sections will discuss these two processes; these processes constitute further theoretical support to the analysis in this thesis.

2.2.1 The macro-level political processes

By embracing the social and ecological model discussed in the previous chapter, residential areas as proximate environmental determinants of health cease to be conceptualised as isolated islands and are affected by various broader social, political, economic, and historical forces (Pearce, Mitchell, & Shortt, 2015).

Residential areas are part of a wider urban or rural area, country, region, and global ecosystem. All these scales and contexts play a role in shaping the physical and social environment and the population. Each level of the system or component of the hierarchy can impact, or be impacted by, the whole ecosystem in a reciprocal relationship (Barton and Grant, 2006). For example, public policy might affect individuals living conditions and choices, air pollution, and climate change (Deryugina and Molitor, 2021).

The political and political economy processes at the national and global levels are at the top of the hierarchy of forces that shape places and the distribution of people across places (Pearce *et al.*, 2010; Ottersen *et al.*, 2014; Walsh *et al.*, 2017; Bambra, Smith and Pearce, 2019). Galster (2012) proposed two mechanisms connecting area effects to these macro-level factors: geographical and institutional. The geographical location of an area within the broader socio-political and economic system determines aspects such as employment and service opportunities. For example, areas might be situated in administrative bodies that differ in governance, policies, labour market and public services, which significantly impact the distribution, functionality and accessibility of various socio-economic and material resources and challenges (Galster, 2012; Ottersen *et al.*, 2014). The institutional mechanisms refer, for example, to place-based stigmatisation and variation between areas in quantity and quality of public and private institutional resources and investment. An area could belong to a jurisdiction with a corrupt or dysfunctional governing system that provides poor public services and investment. Studies showed that socio-economically disadvantaged small areas in more disadvantaged broader geographical contexts have higher cases of illness than small areas with similar levels of disadvantage but located in less deprived broader contexts (Curtis and Jones, 1998).

Another important dimension includes socio-cultural and historical mechanisms. These refer to the ecology of social processes, structures, ideologies, and histories that form the basis of local and regional cultures. These aspects can define specific areas by shared identities, attitudes, affiliations, social roles, and behaviours (Duncan, Jones and Moon, 1998). As distinct from the micro-social processes between individuals, these describe the collective social functioning, norms, and attitudes bounded in certain places, which shape places and people (Macintyre, Ellaway and Cummins, 2002). For example, people in specific locations may have a shared culture that stigmatizes mental health problems, discouraging establishing mental health centres and discouraging individuals from seeking therapy, even if mental health centres are found in these places.

In many instances, political factors create social, economic or built environments that further intensify the vulnerability and exclusion of certain groups (Chaaban *et al.*, 2010; Mah and Rivers, 2016). Sometimes, other, more complex political forces profoundly impact places and individuals. For example, conflicts, forced displacement, political persecution, foreign invasion or annexing certain places with a new political order might cause an explicit and intense form of disadvantage. The populations affected by these contexts can suffer greatly, psychologically and physically, in both the short and long term. There may also be subsequent marginalisation. These political forces can disadvantage multiple aspects of the local economic, physical and social environments rendering them unsupportive to health and characterise them with restrictions, oppression and violence (Sousa, Kemp and El-Zuhairi, 2019; Hammoudeh *et al.*, 2020).

For example, refugee camps, as a consequence of armed conflicts, can be temporary settings that are primarily informal and only meet basic life needs. However, they are commonly inhabited for many years (with an average of 20 years), forming excluded and structurally marginalised disadvantaged settings with poor living conditions (Ottersen *et al.*, 2014; Bogic, Njoku and Priebe, 2015; Behnke *et al.*, 2020; Wardeh and Marques, 2021). Refugee camps in the oPt were established around 1948-1949 as tent camps and, through the years, replaced by unplanned and poorly built housing structures that remain today.

In chapter four, I will discuss these political forces in the context of the oPt and their different manifestations. One of the objectives of this thesis is to investigate the consequences of living in refugee camps and politically created designations that disadvantage places and may well impact the residents' health.

2.2.2 The combined effects of contextual and personal attributes

There is an intrinsic link between environmental and social differences, and these might synergistically influence individuals' health and well-being. How people relate to features in their areas and how the characteristics of people and places interact in their impact on health is an essential component of the relationship between people and places (Duncan, Jones and Moon, 1998; Cummins *et al.*, 2007).

Whilst the impacts of demographic and social characteristics on health are well established, research has shown that they can be shaped, encouraged or inhibited by the structural or socio-environmental factors embedded within the places where people live (Cavazzoni, Fiorini, Shoman, Diab, & Veronese, 2021; Stafford, Bartley, Mitchell, & Marmot, 2001). Thus, the health effects of holding particular personal characteristics or being in a particular social group may differ depending on contextual factors. Additionally, these contextual factors may influence health differently depending on individual-level characteristics such as social position or age (Merlo, 2011).

Several pathways might explain the interaction between personal and contextual factors. Diderichsen, Hallqvist, & Whitehead (2019) proposed the concept of differential vulnerability as a mechanism that may underlie the interaction between personal and contextual factors in their relationship with health. Their model includes three dimensions; first, the degree of exposure to environmental influences might differ between individuals. This might be related to factors such as duration, dose and proximity to sources of exposure (Brulle and Pellow, 2006). For example, personal activity patterns differ by age, sex and socioeconomic status (McLafferty, 2020). Females, older and poorer people may spend more time in their areas of residence, increasing their exposure there and reducing it in other settings (Vallée *et al.*, 2011; Wolch, Byrne and Newell, 2014). Socioeconomic position is known to be a strong influence here; a study in Glasgow demonstrated that poor people tend to walk in their neighbourhood more than affluent people, increasing their exposure to local environmental factors (Macintyre and Ellaway, 1998).

Exposure factors might also be related to the degree of dependence on the residential context, which may vary according to personal and social differences between people (Frohlich, 2013). For example, poor or older people tend to be more dependent on their neighbourhood's services and facilities (Stafford and Marmot, 2003; McLafferty, 2020). The more dependent the individual, the more the dose, duration, and proximity.

Proximity does not only refer to physical proximity but also social proximity. Individuals' specific social and socioeconomic characteristics can be essential in relating and interacting with features in their environment. For example, Cummins et al. (2007) demonstrated that healthy food resources in the local environment are inaccessible for certain individuals or groups because they are poor and cannot afford them. It is also relevant in the other direction, where poor individuals may be drawn to certain exposures because they are affordable or comforting, but these may harm their health.

Second, people differ in their capacity to respond or adapt to contextual influences. This pathway is related to the concept of agency and self-efficacy, or the power to cope with or change the exposures. For example, the negative influence on health from living in a resource-poor area can be mitigated by personal or social mechanisms that the residents do not equally share. Personal attributes such as poverty or frailty might reduce the adaptability to environmental stressors (Blay, Schulz and Mentz, 2015), thus altering their impact on the health of the residents.

Third, some individuals might be more susceptible to adverse environmental exposures than others. For example, from a life course perspective, environmental exposures can harm health differently across age groups. Children and older people are more at risk for some exposures because of their biological characteristics (Swope and Hernández, 2019). Another example is that people with health problems might be more susceptible to specific environmental exposures.

For instance, asthmatics are more vulnerable to air pollution (Guarnieri and Balmes, 2014), and obese people are more susceptible to heat stress (Kenny *et al.*, 2010).

Experiences are also relevant to features that might potentially harm health, such as aspects related to historical or socio-political oppression, with refugee camps as a good example. People living in these disadvantaged and marginalized contexts are also more likely to experience multiple vulnerabilities via all these pathways that interact and exacerbate the health risks of environmental exposure throughout their life course. Some health problems, such as asthma, are associated with both social and ecological exposures; thus, the interaction of different factors may amplify the effects of environmental factors on health (Swope and Hernández, 2019). Moreover, the stress related to exposure to such multiple disadvantages may have cumulative effects that can further inflict more damage to health. This has been referred to as the ‘weathering effect’ (Geronimus *et al.*, 2006).

A core idea from human geography and urban sociology is that places are not just a collection of objects but rather settings full of meanings and experiences of places and their attributes. Places may be represented conceptually differently by individuals, depending on various cognitive and functional processes that connect people with places (Cummins *et al.*, 2007; Christensen, Mygind and Bentsen, 2015). People may have different sensitivities to environmental factors due to differences in their experience, perception, and appreciation of the environment. For example, a study found that poor individuals can perceive their neighbourhood as worse than rich people (Kowitt *et al.*, 2020). This matters because a better perception of the neighbourhood acts as a buffer from environmental stressors (Fong, Cruwys, Haslam, & Haslam, 2019).

In summary, there are many factors that could create an interactive relationship between individual and area characteristics in their association with health outcomes. In this research, I will investigate the combined effects of individual-level demographic and socioeconomic factors and the area-level characteristics of interest in this thesis. In the following chapter, I will discuss this relationship in the context of international evidence.

2.3 Conclusion

In this chapter, I discussed theoretical and methodological considerations in the research connecting places with health. In the first section, I argued that the multi-level approach that separates the compositional and contextual factors is needed to investigate the area-level factors that influence health. Then I discussed the macro-level factors at the top of the hierarchy of factors that influence the population's health. Finally, I discussed the pathways through which contextual factors might differentially affect the health of individuals depending on their characteristics.

The theoretical discussion I have presented thus far helps us understand how places impact the health of individuals and justify the approach adopted in this research. These can be summarised in three points. First, the unequal distribution of social and physical contextual features across areas might disproportionately affect people's health over and above personal characteristics. Such an assumption helps decipher the place-based determinants of health. Second, broader macro-level factors shape places where people live, ultimately shaping their health. Recognising these factors is essential for our understanding of place-based effects. Third, personal and contextual influences may interact in their association with health outcomes. Exploring the interaction between individuals and their context enables us to understand the complexity of how health is shaped by the interrelationship of variables at different levels.

Considering these three points is essential to understand the relationship between places and health and the mechanisms underlying it. The following chapter will discuss research studies connecting health and place related to each of these points, focusing on the objectives of this thesis. It will place these processes in the context of international and regional empirical evidence.

Chapter three: Scientific literature review

In chapter one, I briefly discussed some of the geographical aspects of population health, the social and ecological model of health and the concept of the 'area effect' on health. I demonstrated the lack of evidence on the place-based determinants stemming from less developed countries, particularly the Arab World, and why it is problematic. Finally, I identified the urban attributes of interest in this thesis: the politically created area disadvantage and urban green space, and why I selected to investigate them.

The aim of this chapter is to review the scientific literature focusing on the issues and aspects most relevant to this thesis to answer the following questions:

- What does the international evidence indicate about the relationship between area disadvantage and health outcomes? What does the international evidence indicate about the relationship between green space and health outcomes?

- What does the international evidence indicate about the interaction between individual-level demographic and socioeconomic characteristics with the area-level features in their relationship with health outcomes?

To answer these questions, I conducted two literature reviews. Firstly, a broad review of the literature exploring the relationships between both area disadvantage and green space with health. This focused largely on evidence from published reviews. Secondly, a detailed review of all primary place-based environmental and sociodemographic studies in the Arab World. In the following section, I will discuss the different sources of literature included in this review and the methods I used in the literature search.

3.1 Literature used in the review

An initial scoping review was conducted at the beginning of the research. This scoping review introduced me to the literature on the subject and what has been studied in the oPt and the region. I also delved into international evidence and continued to search and review the literature throughout the course of my PhD to keep abreast of new developments in the field. These mainly were reached through a manual search on Google, Google scholar and the University of Glasgow library. Thus, I gathered much of the materials that supported the literature review throughout the PhD study till the thesis submission on September 2022. I also conducted a more formal literature search in April 2021.

This review includes published peer-reviewed papers, books, and grey literature such as reports and documents from various organisations and agencies (i.e., governmental, technical, World Bank, World Health Organisation, United Nations, and others).

I conducted two structured literature searches: one at the international level and a second specific search for the context of the oPt and Arab World. A public health information scientist supported the process by providing advice in selecting the databases, developing key search terms, and ensuring that they sufficiently captured the needed information. This section will discuss the two literature searches, including the search strategy and terms, the databases, exclusion criteria and search results.

3.1.1 Search one: international literature

I searched for literature about health and place and the sub-topics of interest in this thesis. As recommended for a proper literature search, I structured the search question and strategy using the Population Exposure Outcome (PEO) model (Aromataris and Riitano, 2014). The main search questions related to the association between health outcomes with:

- areas of residence,

- politically created disadvantaged contexts (refugee camps and political areas classification),
- and urban green space.

Given that these are broad search questions (not specific health outcomes, no restriction on the population and its global scale), they returned a large number of hits. For example, the Medline database retrieved around 25000 papers. Therefore, I restricted the search for international evidence to reviews and meta-analyses only. Many systematic reviews and meta-analyses have already rigorously summarised the topics of interest in this thesis and appraised the evidence comprehensively, extensively, and systematically. They are at the top of the pyramid of evidence synthesis (Murad *et al.*, 2016). Thus, relying on existing reviews was practical and time-resource efficient. However, the literature review in this thesis did not exclusively rely on review papers; I also included key original research studies amassed throughout the PhD.

3.1.1.1 Search strategy and terms used to identify reviews

I conducted the literature search on April 29th, 2021, in four databases:

- Medline (1946 to April week 5, 2021) through the OVID interface.
- Embase (1947-present, updated daily) through the OVID interface.
- International Bibliography of the Social Sciences (IBSSS) through ProQuest.
- Social Science Citation indexes through Web of Science.

I selected the search terms to cover a variety of health outcomes and mortality, along with the most common terms used to describe the area's effects on health. I added specific terms to focus more on residential areas and the place-based effects of interest in this thesis (green space, political classification, and refugee camps).

In addition to these restrictions on the exposure/outcome terms, the searches in the four databases were restricted to reviews and meta-analyses. I did not limit the search to systematic reviews because other types, such as scoping and narrative reviews, might be valuable. Finally, I restricted the keyword search to the titles only as including the abstracts returned more than 2000 studies.

I added additional search terms in the medical subject headings (MeSH) in the Medline and Embase databases. This step methodologically expanded the search by adding specific vocabulary (identified by the public health information scientist), which facilitated searching for the material indexed by these databases.

Table 3-1 presents the search terms and the search steps conducted in the four databases. The search terms were adapted to each database accordingly. The first two steps represented the outcomes, and the third step represented the exposures. Step four further restricted the search for reviews and meta-analyses. Step 5 defined the final search algorithm combining all the previous steps. Appendix A provides a detailed description of each step of the search and the results in the four databases.

Table 3-1:Search terms and steps to identify reviews

1	(morbidity OR Mental health OR Public health OR Health status) – [MESH Terms]
2	(chronic disease*[4] OR chronic illness* OR morbidity OR mortality OR Death OR “physical health” OR “general health” OR “self-reported health” OR “mental illness*” OR “mental health” OR non-communicable disease* or morbidity or physical illness or mental illness* or well-being or well-being or heart disease* or hypertens* or blood pressure or Diabet* or Asthma or stroke or cancer*) title
3	(neighborhood* OR neighbourhood* OR area-level OR “area level” OR place* OR “residential area*” OR “urban design” OR “urban environment” OR “natural environment*” OR Greenspace* OR “green space*” OR “green environment” OR “open space*” OR “open public space*” OR “green area*” OR greenery OR “green vegetation” OR “land cover” OR “tree cover” OR “urban trees” OR forest* OR woodland* OR parks OR gardens OR “political class*” OR “refugee camp*”) title
4	(Review OR Meta-analysis) title and Mesh
5	**Search in [(1 OR 2) AND 3 AND 4]**

3.1.1.2 Exclusion criteria

The excluded materials during the screening process were the following: papers not in the English language; literature with non-related topics such as those specific to industrial and climatic factors; literature about health care settings and local health promotion and screening programs; literature specific to endemics/epidemics of infectious diseases; review protocols; and literature on specific green space exposure such as tropical forest and forest bathing.

3.1.1.3 Screening results

I screened all the material retrieved by the literature search. Figure 3-1 shows a simplified flow diagram that summarises the screening process of the 592 initially identified records. The literature screening identified 151 reviews from the four databases. I already came across most of these reviews before conducting the

[4] * Denote the term and any derivatives of that term. For example, disease* include disease and diseases, etc.

literature search. A total of 32 reviews were new, mainly recent publications. I should note that this number included material that was not directly related to the search questions. These were necessary, such as methodological reviews and reviews describing refugee camps' contexts (without linking them to health outcomes).

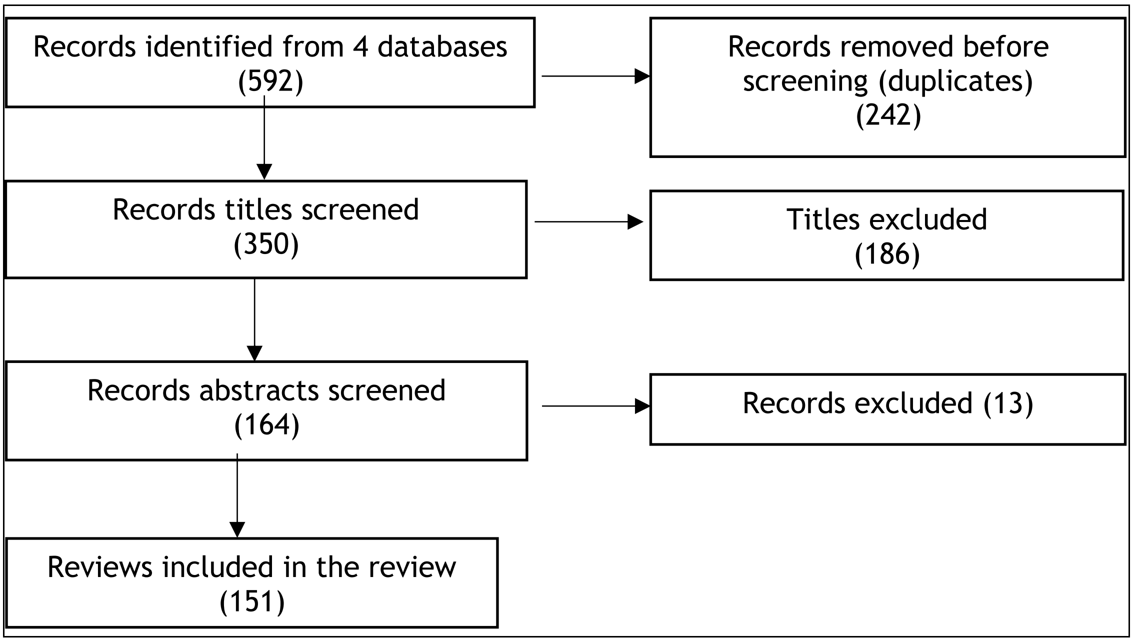

Figure 3-1: Flow diagram of the search for international literature

3.1.2 Search two: Search for literature specific to the Arab World

The literature about the relationship between place-based features and health in the Arab World is scarce. I conducted a literature search with similar scientific rigour to the first search but with a more specific focus on the Arab world's context. Thus, it broadened and redefined some of the search terms and components.

The search in the four databases was as the following:

- Medline (1946 to April week 5, 2021) through OVID interface: the search was on the title, abstract, subject heading, and medical subject heading (MeSH) terms.

- Embase (1947-present, updated daily) through the OVID interface: the search was on the title, abstract and subject heading.

- International Bibliography of the Social Sciences IBSSS through ProQuest: the search was anywhere except the full text.

- Social Science Citation indexes through Web of Science: The search was conducted on the topic, including title, abstract, keywords, and keywords plus. The keyword field is the keywords provided by the authors that describe the subject that the paper covers. The keyword plus is the expanded terms that branch from the main keyword obtained through an algorithm of the cited records and bibliographies of the paper.

3.1.2.1 Search strategy and terms

Table 3-2 presents the search steps and terms, which I adapted to suit each database. It included six phases: the first step was to search in medical subject heading (MeSH) terms. The second was adding terms on various physical and mental health outcomes, mortality, and common risk factors. The third and fourth steps were to search the terms (and MeSH terms) describing the area characteristics, with more terms specific to the urban green space, built environment and political environment (refugee camps and political classification). The fifth step was to restrict the search to the geographical location of the Arab region. And finally, the sixth step represented the final search algorithm combining the previous steps. Appendix A provides a detailed description of each step of the search and the results in the four databases.

Table 3-2: Search steps and terms for the literature in the Arab World

1	(morbidity OR Mental health OR Public health OR Health status) – [MESH Terms]
2	(disease* OR illness* OR morbidity OR chronic* OR illness OR patholog* OR syndrome OR disorder* OR mortality OR Death OR "physical health" OR "general health" OR "self-reported health" OR "population health" OR hypertens* OR "blood pressure" OR Diabet* OR Asthma OR stroke OR cancer* OR neoplasm* OR pain OR obesity OR "body mass index" OR BMI OR "psychological illness*" OR "psychological disorder*" OR "mental illness*" OR "mental health" OR well-being OR well-being OR "quality of life" OR QOL OR "life satisfaction" OR stress OR anxiety OR depression) **title, abstract and subheading**
3	(residence characteristics OR parks, recreational OR city planning) [MeSH Terms]
4	("built environment*" OR neighborhood* OR neighbourhood* OR "land use" OR contextual OR spatial OR ecological OR area-level OR "area level" OR place* OR "Geographical Information system" OR GIS OR "physical environment" OR "residential area*" OR "urban design" OR "urban infrastructure" OR "urban environment" OR "urban planning" OR "city planning" OR "urban heat" OR "natural environment*" OR Greenspace* OR "green space*" OR "green environment" OR "open space*" OR "open public space*" OR "green area*" OR greenery OR "green vegetation" OR "land cover" OR "tree cover" OR "urban trees" OR forest* OR woodland* OR parks OR gardens OR "political class*" OR "refugee camp*") title, abstract and subheading
5	("Middle East" OR "North Africa" OR MENA OR "Arab world" OR "Arab region" OR "Arab countries" OR Palestine OR Palestinian* OR "occupied Palestinian territory" OR "West Bank" OR Gaza OR Jordan OR Egypt OR Lebanon OR Syria OR Tunisia OR Morocco OR Libya OR Algeria OR Sudan OR Iraq OR "Saudi Arabia" OR Kuwait OR Qatar OR "United Arab Emirates" OR UAE OR Oman OR Yemen) title, abstract and subheading
6	**Search in [(1 OR 2) AND (3 OR 4) AND 5]**

3.1.2.2 Exclusion criteria

The excluded materials in the screening process were the following: studies not in English, Arabic, and French languages; non-human studies; studies focusing on unrelated topics; studies that investigated specific infectious diseases, industrial, chemical, climatic, or biological risk factors; studies that did not examine the link between exposure and outcome such as descriptive and prevalence studies; studies that examined only the individual-level risk factors and only mentioned contextual factors without investigating them; studies not in the context of the Arab World but on Arab populations living in other countries.

Figure 3-2 shows a simplified flow diagram summarising the 5919 initially identified records screening process from the four databases. Removing the duplicates reduced the number to 4052. After excluding articles through title screening, 351 articles remained. Finally, the abstract screening resulted in eight relevant Arab world studies.

3.1.2.3 Screening results

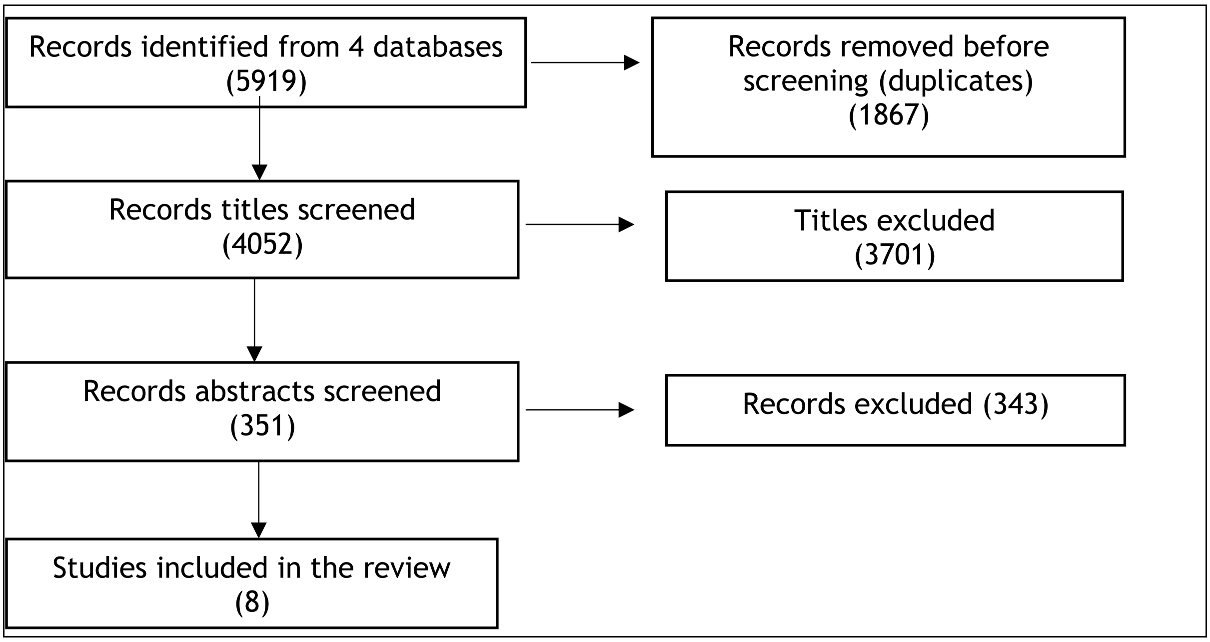

Figure 3-2: Flow diagram of the search of the literature in the Arab World

In the literature search, I found only eight relevant studies in the Arab World region, published between 2011 and 2020, highlighting the scarcity of studies in this context. The research areas of these studies were from: Egypt (3), Syria (1), Morocco (1), Saudi Arabia (2), and the oPt (1). All the studies were cross-sectional. Three studies used subjective environmental measures in an individual-level analysis (Sidawi, Deakin and Al-Hariri, 2016; Afrad and Kawazoe, 2020; Saddik, Al-Masri and Jradi, 2020). One study used both subjective and objective measures of the environment in an ecological analysis (Algoday, Ayad and Saadallah, 2019), and four used objective measurements (Mowafi *et al.*, 2011, 2012; Ahmad *et al.*, 2013;

Bates *et al.*, 2017). Three studies used a multi-level methodology analysing individual and area-level information simultaneously (Mowafi *et al.*, 2011, 2012; Ahmad *et al.*, 2013). The only study from the oPt was a multi-level study that investigated the variation in health between localities but without including area-level characteristics (Bates *et al.*, 2017). Despite that, this study was relevant to this thesis. A table summary of the eight studies found in the Arab World is presented in Appendix B.

3.2 The empirical evidence for the contextual influences on health

This section is structured into three parts relevant to the chapter's objectives (mentioned above); the first part is about the association between area disadvantage and health outcomes. This is relevant to the politically created disadvantaged contexts in the oPt, which the thesis aims to investigate with health outcomes. The second part of the review concerns the association between urban green space (as a feature of the physical environment of interest in this thesis) and health outcomes. The third section explores the interaction between the area-level characteristics and individual-level demographic and socioeconomic factors, namely, age, sex, and socioeconomic status.

3.2.1 Area socioeconomic disadvantage and health

In this section, I will discuss the consequences on health and well-being for the people living in disadvantaged areas. First, I will review the international and regional evidence on the links between area-level disadvantage and health outcomes. Second, I will focus on two aspects of politically created disadvantage: the form of area disadvantage of interest in this thesis and the consequence of these contexts on the health of people living there.

3.2.1.1 The evidence linking area disadvantage with health outcomes

Research has demonstrated that people in poor or disadvantaged areas (with their different definitions) have a higher risk of physical and mental health problems, mortality, and a higher prevalence of health-harming behaviours than those in well-off areas. Overall, there is an agreement that area disadvantage is an important determinant of health (see, for example: Diez Roux, Kershaw and Lisabeth, 2008; Ross, 2009; Meijer *et al.*, 2012; Bambra, 2016; Russell *et al.*, 2016; Toms *et al.*, 2020). However, the effect sizes and the variance explained by the area-level measures relatively varied and sometimes were inconsistent, and on many occasions, the effect sizes were small. These are discussed below.

3.2.1.1.1 <u>Area disadvantage and mental health outcomes</u>

In the US Moving to Opportunity experimental studies[5], researchers found that adults who moved from a disadvantaged area to a more advantaged one had lower rates of psychological stress and higher levels of subjective well-being (Kling, Liebman and Katz, 2007; Ludwig *et al.*, 2013). However, the effect sizes on these health outcomes and places varied between studies, sometimes considerably. This was possibly related to the measurement lag and dose effect, as highlighted by Moulton, Peck, & Dillman (2014), who investigated a subset of the participants who moved to more advantaged areas for a longer time. They found larger effect sizes on well-being than the effect sizes of the studies mentioned above, which included participants with different and sometimes short follow-up periods after moving to a more advantaged area.

[5] Moving to Opportunity housing mobility scheme was a source of many experimental and quasi-experimental studies that linked area disadvantage with health and well-being outcomes. Implemented in 1994 in five US cities, it operated by randomising 4600 families who lived in public housing in highly disadvantaged areas into three groups: group one had access to housing vouchers that could be used only to move to less disadvantaged areas, in addition to housing mobility counselling; group two had access to non-constrained coupons; group three had no extra assistance (control group). After a year, group one lived in areas with a poverty rate of 21%, group two lived in areas with a 35% poverty rate, and group three lived in areas with a 50% poverty rate (Ludwig et al., 2013). Surveys and investigations were conducted before randomisation and after 1-3 years, 4-7 years and 10-15 years of randomisation.

Many observational studies found a significant positive association between various measures of area socioeconomic disadvantage and mental health outcomes such as depression and anxiety disorders (Julien *et al.*, 2012; Blair *et al.*, 2014; Remes *et al.*, 2017). For example, living in disadvantaged areas of London and southeast England (measured by the Townsend index of deprivation) was found to be significantly associated with lower satisfaction with standards of living and a higher risk of depression (measured by GHQ-30[6]), independent of individual-level socioeconomic position (Stafford & Marmot, 2003). However, a limitation of this study is that it was based on census data collected almost seven years before the health data. Other studies found no association between area socioeconomic disadvantage and depression beyond individual-level indicators, including one on the Hispanic community in the USA (Holmgren *et al.*, 2021). However, this study demonstrated a high correlation between individual and neighbourhood measures, highlighting the issues of separating contributions at different levels.

The systematic reviews of the relationship between area-socioeconomic disadvantage and mental health outcomes demonstrated inconsistent evidence and incomparable effect sizes (for reasons discussed later in this chapter). For example, evidence for the association between area disadvantage and depression was inconsistent in a meta-analysis of longitudinal studies (Richardson et al., 2015). In studies included in this meta-analysis with follow-up of fewer than five years, the association between area disadvantage and depression was significant. The pooled effect indicated that those living in a disadvantaged area have a 28% higher likelihood of depressive symptoms than those in an advantaged area. This association was non-significant for studies with more than five years of follow-up. Yet, studies with shorter follow-up periods were highly heterogeneous; thus, the pooling result might be biased compared to more homogeneity in the studies with longer than five years of follow-up; more trusted evidence.

At the same time, consistent and robust evidence was reported by another systematic review on the association between living in a disadvantaged area and

[6] GHQ-30 is a version of the General Health Questionnaire that measures common mental health problems and rates individuals' psychiatric status.

self-harm, suicidal behaviour and ideation (Cairns, Graham and Bambra, 2017). However, this review was exclusive to the European context and included only one longitudinal study; thus, the findings are not representative and limited in proving causality.

Area socioeconomic disadvantage was also found to be associated with brain and cognitive health. For example, a study in the USA investigated the brain of deceased individuals and found that living in the most disadvantaged area (or the highest decile in the Area Deprivation Index) was associated with 118% higher odds of Alzheimer's disease neuropathy (Powell *et al.*, 2020). While a systematic review found that area disadvantage was related to cognitive functions for older people (Wu, Prina and Brayne, 2015). However, this study was based chiefly on individual-level studies that did not account for dependence on areas, which might distort the associations.

3.2.1.1.2 Area-disadvantage with physical health outcomes and mortality

Studies have demonstrated that area disadvantage is associated with various physical health problems, such as coronary heart disease (Diez-Roux et al., 1997; Juan Merlo et al., 2013), diabetes (Kling, Liebman and Katz, 2007; Ludwig *et al.*, 2013; Mezuk *et al.*, 2013), stroke (Kim *et al.*, 2021), mortality outcomes (Votruba and Kling, 2009; Meijer *et al.*, 2012) and with chronic diseases risk factors such as smoking, hypertension, obesity, fasting blood sugar levels, cholesterol, lipoprotein (Diez Roux, Kershaw and Lisabeth, 2008; Cockerham, Hamby and Oates, 2017; Fitzpatrick *et al.*, 2018; Toms *et al.*, 2020; Savin *et al.*, 2021). For example, a multi-level study in Egypt found that a higher average educational level in the residential areas of Cairo was associated with lower body mass index (BMI) compared to areas with lower average academic levels (Mowafi *et al.*, 2011).

Studies with an experimental and quasi-experimental design found that adults who moved from disadvantaged areas to more advantaged areas developed lower rates of obesity and diabetes (Kling, Liebman and Katz, 2007; Ludwig *et al.*, 2013) and lower risk of ischemic heart disease (Merlo *et al.*, 2013). At the same time, young males had a lower risk of all-cause and homicide mortality (Votruba and Kling, 2009). However, moving out from disadvantaged areas did not affect other physical health outcomes included in these studies, such as asthma and injuries. The study by Votruba & Kling (2009) only found this association when measuring disadvantage via the percentage of residents with higher education and not for other measures such as employment and poverty rate or average income.

Systematic reviews and meta-analyses of observational studies also provided evidence on the link between area disadvantage with physical health and mortality (Meijer *et al.*, 2012; Spencer, Blackburn and Read, 2015; Arcaya *et al.*, 2016; Kim *et al.*, 2021). For example, a meta-analysis found that living in disadvantaged areas was associated with a pooled 141% higher likelihood of physical activity limiting asthma in young children (Spencer, Blackburn and Read, 2015). Another systematic review and meta-analysis by Meijer, Röhl, Bloomfield, & Grittner (2012), found that 22 out of the 24 multi-level studies included in their analysis showed a significant association between area-level disadvantage and all-cause mortality, over and above their individual level conditions. However, these studies had high levels of heterogeneity, primarily because of different measures of area disadvantage (whether individual measures such as percentage of unemployed or different deprivations indices) and varying causes of death in the included studies, which could harm the validity of the meta-analysis. Noting that, Spencer et al. (2015) conducted a sensitivity analysis and confirmed the validity of their evidence.

In conclusion, evidence from various study designs supports a link between living in a disadvantaged context and negative physical and mental health outcomes and mortality. However, and for several reasons, including heterogeneity in exposure/outcome measures and studies' design and population, there is a considerable variation in the strength of this relationship across studies, and some found no association. In this thesis, my interest is in the politically created disadvantage, discussed in the following section with health outcomes.

3.2.1.2 Evidence of politically created disadvantages and health outcomes

In this section and the following studies found in the literature search, I will focus on the literature about the link between health and two forms of politically created disadvantages relevant to the analysis of this thesis. First, I will discuss health in the context of displaced communities and life in refugee camps. Second, I will discuss the political forces imposed on a local population by foreign powers and their impact on the population health in these places.

3.2.1.2.1 Refugee camps and population health outcomes

Worldwide evidence demonstrates substantial, cumulative, and negative impacts of refugee camps on physical and mental health outcomes.

For example, a study in sub-Saharan Africa compared refugees living in long-term refugee camps with refugees living in the city outside refugee camps using the World Health Organization's (WHO) Quality of Life scale (brief version) (Crea, Calvo and Loughry, 2014). They found that living inside a refugee camp was associated with lower environmental well-being and lower satisfaction with physical health (physical pain, need for medical treatment, enough energy, mobility, work, and sleep).

Studies have also highlighted the importance of the post-migration context in determining mental health outcomes and reducing the adverse effects of conditions before and during migration, which both have long-term consequences on health (Hynie, 2018; Scharpf *et al.*, 2021). For example, a quasi-experimental study in Denmark by Hamad et al., 2020, investigated the effect of placing individuals who came to Denmark as refugees from various countries (including the oPt) between 1986 and 1998 into areas that differed in disadvantage status. The authors found that placing these refugees in disadvantaged areas was associated with an increased risk of hypertension, hyperlipidaemia, diabetes, and myocardial infarction. This shows the negative impact of area disadvantage on those already disadvantaged by their refugee status. However, these studies and reviews were about refugees but were not specific to the context of refugee camps.

Studies focusing exclusively on refugee camps concluded that living in this disadvantaged context was harmful to health (Amara and Aljunid, 2014; Crea, Calvo and Loughry, 2014; Harsha *et al.*, 2016; Jonassen *et al.*, 2018). A systematic review found a strong link between living in refugee camps and a higher likelihood of morbidity and mortality from acute respiratory diseases (Bellos *et al.*, 2010). However, this evidence was limited by the absence of comparison with non-refugee settings. A nationally representative study in the oPt found that living in a refugee camp was associated with a 40% higher likelihood of self-reported chronic diseases compared with living outside refugee camps after adjusting for demographic and socioeconomic characteristics (Jonassen *et al.*, 2018). This study echoed a previous descriptive report in Lebanon which found that 72% of the households in Palestinian refugee camps include members with a chronic illness (Chaaban *et al.*, 2010). Other health-related outcomes were found to be associated with living in Palestinian refugee camps, such as the higher likelihood of obesity, especially among females (Damiri *et al.*, 2018), cardiovascular diseases and diabetes (Abukhdeir *et al.*, 2013); irritable bowel syndrome (Qumseya *et al.*, 2014); and lower rates of well-being (Harsha *et al.*, 2016).

Mental disorders and psychological health problems such as distress, depression and anxiety are highly prevalent in refugee camps, especially in low-income countries (Bogic, Njoku and Priebe, 2015; Li, Liddell and Nickerson, 2016; Scharpf *et al.*, 2021).

However, studies in less developed countries where most refugee camps are located are still insufficient and mainly of low quality (Bogic, Njoku and Priebe, 2015; Vossoughi *et al.*, 2018; Behnke *et al.*, 2020; Scharpf *et al.*, 2021). This perhaps stems from the considerable economic, political, practical and ethical challenges in conducting research and interventions in these contexts (Scharpf *et al.*, 2021). Furthermore, whilst evidence suggests health was poor in refugee camps, few studies explored why. Many studies about health outcomes in refugee camps were descriptive. They did not determine if the difference in health outcomes is statistically significant or driven by ecological factors and what these factors are.

Reports from the Palestinian context highlighted many environmental disadvantages in refugee camps, such as overcrowding, inadequate housing conditions, poor built environment infrastructure and planning, and scarcity of open and green spaces (UNEP, 2020). These problems are shared with refugee camps worldwide (Behnke *et al.*, 2020). However, most studies that investigated refugee camps focused on services and health care, with few addressing other social and environmental conditions (Hynie, 2018; Emerson *et al.*, 2021). For example, a review of the literature on refugees in Malaysia found eleven studies on the living condition of refugees. Nine of these addressed access to services (mainly health care services). Only one 'qualitative' study focused on the social environment, documenting the discrimination and stereotyping experienced by refugee children (De Smalen *et al.*, 2021). Although access to services and health care factors are vital to the health of those living in refugee camps, understanding the impact of the broader social and physical environment could provide further evidence to improve the health of this vulnerable population. This underpins the need to investigate the contexts of refugee camps, which is one of the contributions of this thesis.

Reviews of refugee camps worldwide report many social problems in refugee camps, such as discrimination and low social support. However, poverty and socioeconomic disadvantage remain critical (Hynie, 2018). One study was conducted on the population of Palestinian refugees in Jordan. The authors compared the physical and social living conditions of refugee camps (40342 families) and outside refugee camps (8526 families) using subjective measures of environmental features (Tiltnes and Zhang, 2013). In addition to the problems mentioned above, they found that the people living in a refugee camp reported lower safety, lower satisfaction with their residential areas and higher violence and crime.

In summary, refugee camps are unfavourable contexts that potentially harm health. Few studies have examined the contextual factors in refugee camps, especially the physical environment, that could be responsible for the adverse health outcomes. One objective of this thesis is to investigate the impact of the context of refugee camps compared to other areas in the twin cities of Ramallah and Albireh and to examine the role of green space in this disadvantaged context. The following chapter will provide a more detailed description of refugee camps in the oPt and some information about their history and current conditions.

3.2.1.2.2 Political areas designations

The second indicator of area disadvantage that is of interest in this thesis is that caused by imposing a political system which fails to serve the liveability and welfare of the population and operates to serve other purposes that might adversely affect living conditions.

It is acknowledged that political systems and their processes and agendas have the power to shape and create the population's living conditions. One example is the political division of Germany from the sixties until the late eighties in the last century. Living conditions between East and West Germany differed considerably because of different political regimes. West Germany had much better-living conditions and less area-level deprivation than East Germany, reflected in multiple health outcomes. Shortly after the unification of Germany, the Western federal region had significantly higher life expectancy and lower non-communicable diseases than the Eastern region (Lampert *et al.*, 2019). Many of these differences were attenuated in the years after reunification. Currently, the difference is non-significant, confirming that the main reason behind the health disparities was the political systems and living conditions they imposed. These findings might be related to compositional factors and the segregation of groups of people. However, studies found an independent effect of each region's social and physical contextual features, which were ultimately related to the historical socio-political conditions (Lampert *et al.*, 2019).

The oPt is similarly fragmented into different political classifications that designate different political orders in Palestinian communities. These will be discussed further in the following chapter. Unfortunately, there are no studies in the oPt on the impact of these different political designations, a gap this thesis seeks to fill.

3.2.1.3 Issues related to the evidence linking area disadvantage with health outcomes

Features common to the reviews discussed so far in this chapter are that the evidence linking area disadvantage and health is both modest and inconsistent (Kim *et al.*, 2021). This might be for several reasons.

First, it might stem from the methodological limitations of observational studies and that most do not satisfy the criteria of causal inference. These include, for example, selection bias, not accounting for residential mobility and selective migration, reliance on fixed (randomly) defined boundaries, and the assumption that places do not change over time (Cummins et al., 2007; Juan Merlo et al., 2013). Some experimental and quasi-experimental studies avoided many of these causal problems, such as studies based on Gautreaux and Moving to Opportunity housing mobility schemes (for more information about these studies, see Chyn and Katz (2021)). However, these studies were not free of limitations. For example, scholars criticised the Moving to Opportunity studies for not properly accounting for the characteristics of the areas before and after randomisation (Oakes, 2004; Galster and Sharkey, 2017). Also, the intervention in moving individuals to advantaged areas did not target the consequences of living in a disadvantaged context or the specific aspects in the disadvantaged areas that were relevant to health (Diez Roux and Mair, 2010). Nevertheless, these studies provided the most robust evidence available of a possible causal relationship between area disadvantage and health outcomes.

Second, systematic reviews reported a common problem of methodological heterogeneity between observational studies, making evidence synthesis a problematic task. There are different sources of this heterogeneity, such as in the measurement and conceptualisation of the socioeconomic disadvantage, the sizes of studied areas and other aspects (Pearce *et al.*, 2010). For example, the systematic review conducted by Richardson et al.(2015) concluded that the inconsistent evidence of a longitudinal association between area socioeconomic conditions and depression was due to the heterogeneity in the study areas and times of follow-up.

Third, there are many complexities in the relationship between health and places, many mediating and confounding factors, which might drive the heterogeneity in studies and the inconsistent evidence. For example, there is consistent longitudinal evidence in systematic reviews examining the relationship between housing disadvantage and mental health, which has relatively fewer methodological challenges (Singh *et al.*, 2019). However, this can also indicate that housing is a stronger determinant of health.

Finally, as discussed in chapter one, the scarcity of evidence from developing countries is another limitation for conclusive evidence. Even with appropriate designs for causal inference, the evidence base is not representative of contexts with different political, economic, social, cultural and environmental conditions (Tunstall *et al.*, 2007; Singh *et al.*, 2019). All these factors might be very different in developing countries compared to high-income developed towns and cities. For example, disadvantaged areas in developing countries, such as slums or refugee camps, have substantially poorer services and infrastructure, even basic human needs (e.g., access to water), compared to disadvantaged areas in developed countries (e.g., the United Kingdom). Therefore, the evidence of contextual effects on health in high-income countries might be considerably different from those in low-middle-income countries.

3.2.1.4 Summary of the section:

Studies have found various mental and physical health and mortality outcomes adversely related to living in socioeconomically disadvantaged areas. However, this line of research has several challenges and limitations that prevent the production of more robust evidence. First and most importantly, there are challenges in creating evidence for causal links between the socioeconomic environment and individual-level outcomes. Second, even in studies that addressed causality, problems related to unmeasured contextual and individual-level factors might confound this association. Third, very few studies on the link between area disadvantage and health were conducted in developing countries.

One of the explicit and more severe forms of area disadvantage is the politically created disadvantages, whether in the form of refugee camps or political classifications of land. These contexts create adverse living conditions that could potentially harm the population's health. However, research connecting these politically created contexts with individual-level health outcomes is sparse; what specific area-level features mainly relate to health outcomes was not yet ascertained.

The following section will address urban green space, the feature of the physical environment of interest in this thesis, alongside the political elements in the twin cities of Ramallah and Albireh. It will discuss green space as a vital element of the urban environment and international evidence of its benefit for population health and well-being.

3.2.2 Urban green space and human health

Green space is the second urban feature I will investigate in the twin cities of Ramallah and Albireh. In chapter one, I stated the reasons for my interest in urban green space in this thesis. This section will review international literature on the link between green space and health outcomes. But first, this section will start with the definition of green space, and how it is commonly measured and then discuss the pathways linking green space and population health.

3.2.2.1 Definition and measurement of green space

No specific definition is accepted or used as a standard in studies investigating the link between green space and health outcomes (Taylor and Hochuli, 2017). Some researchers defined green spaces as public places or settings such as parks or gardens, and other studies use grasslands and woodlands in an area or around people's homes.

Researchers also used several measures to quantify exposures to green space, which can be mainly classified into objective and subjective measures. Objective measures usually require Geographic Information System data (GIS) about the availability and accessibility of green spaces. These can be measures of the amount or density of green space or distance to the nearest green space (such as gardens and parks). A common way to measure green space availability is using land cover data or vegetation indexes such as the Normalised Difference Vegetation Index (NDVI)[7]. NDVI is most commonly used in studies because it is relatively easy to obtain and valuable for producing a single measure that can be repeated in different places and contexts (Markevych *et al.*, 2017; Kondo *et al.*, 2018). All these objective measures have strengths and limitations and can be used at different spatial scales. For example, NDVI is limited in terms of capturing variations between small areas and differences in vegetation types (e.g., trees and grasslands or public and park, etc.). Subjective measures are usually conducted through surveys based on people's perceptions of green space close to their homes (quantity and quality) or in their areas, the accessibility and distance to green spaces, or how frequently they visit green space.

The subjective and objective measures of green space might differ considerably. Objective measures are more about the existence of green space surrounding individuals but might not correspond to what they report or perceive. For example, there could be several green spaces around the residence of a particular individual; however, according to the subjective views of these individuals, there is only one green space. This is probably because they only travel in one direction or view other green spaces as further away. Subjective measures also have a social and cultural aspect, such as how much green space is valued in society or the culture (Hunter & Luck, 2015).

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[7] NDVI is a remote sensing tool that uses the sunlight reflected by the green spaces and categorises the wavelengths by specific colours that indicate the density of green space in an area (Nasa Earth Observatory, 2000).

Similarly, different spatial scales of objective measures might differ because they measure different aspects of the relationship, depending on the pathways linking green space with health and well-being (Markevych *et al.*, 2017); these pathways will be discussed in the following section.

3.2.2.2 Pathways linking residential green space with health and well-being outcomes

Like most place-based features, the relationship between green space and health outcomes is complex. Several mechanisms or explanations for why green space might benefit population health have been proposed and tested. Markevych et al. (2017) summarise these pathways into three interrelated biopsychosocial dimensions: capacity restoration, mitigation of harmful environmental stressors and building capacities.

3.2.2.2.1 Capacity restoration

One proposed dimension of pathways between green space and health is its role in restoration. Contact with or simply viewing green space can promote psychological restoration from stress and reduce stress activation and responses (Ulrich, 1984; Bowler, Buyung-Ali, *et al.*, 2010; Lopes, Lima and Silva, 2020). Thus, being in or seeing green spaces can provide a positive state of mind (emotions and thoughts) that alleviate or stall the physiological, emotional and cognitive responses to psychological stress (Dzhambov *et al.*, 2019; Yang *et al.*, 2022).

Studies provided substantial evidence for these mechanisms, showing that exposure to green space was associated with reduced levels of stress-related physiological responses such as cortisol, blood pressure, heart rate, and muscle tension (Roe *et al.*, 2013; Ward Thompson and Silveirinha de Oliveira, 2016; Rautio *et al.*, 2018; Twohig-Bennett and Jones, 2018). Nieuwenhuijsen et al. (2017), demonstrated that restoration from stress and stress reduction is the most important pathways and has the most consistent evidence.

Exposure to green space has been shown to be associated with attention restoration. It can enable people to voluntarily direct attention and restrain distractions. It fosters a state of mindfulness and well-being by effortlessly focusing on the 'external world' rather than on the self. Whereby concentration on the self is associated with more stress and depression, especially in people living in deprivation (Roe *et al.*, 2013; Trapasso, 2021).

3.2.2.2.2 Mitigation of harmful environmental exposures

Another proposed dimension of pathways between green space and health is its role as a buffer in reducing harmful environmental exposures, such as air pollutants, urban noise and heat (Hartig *et al.*, 2014; Zupancic, Westmacott and Bulthuis, 2015). For example, some species of trees can improve air quality by removing pollutants and functioning as barriers that block polluted air from streets from reaching nearby residents or commuters (Wolch, Byrne and Newell, 2014; Tong *et al.*, 2015). Most benefits in reducing heat are seen in warmer locations, with lots of evidence from Australia. Similarly, pollution benefits are greater in inner city areas—these highlight context-specific variations in the different pathways.

Evidence suggests that a row of trees, or green wall, can play a role in shielding people from traffic-related noise and mitigating the heat from motorways (Van Renterghem *et al.*, 2015). The concentration of trees in urban parks minimises urban heat in the surrounding metropolitan areas by cooling effects of about one degree Celsius (Bowler, L. Buyung-Ali, *et al.*, 2010). Noise nuisance may also be reduced through the natural sounds that trees provide, such as rustling and bird sounds (Alvarsson, Wiens and Nilsson, 2010; Dzhambov and Dimitrova, 2015).

3.2.2.2.3 Capacity building

The third dimension of pathways between green space and health is its role in building capacities. For example, green space provides pleasant spaces and settings that encourage physical activity, social interaction, and outdoor play, which are all important determinants of health (Kohl *et al.*, 2012; Kondo *et al.*, 2018; Jennings and Bamkole, 2019; Liu *et al.*, 2019).

Studies and reviews have shown an association between green space and different forms of physical activities, such as walking and cycling (James *et al.*, 2015; Barnett *et al.*, 2017; van den Bosch and Ode Sang, 2017; Fong, Hart and James, 2018). Some studies suggested that physical activity in green spaces (green exercise) conveys more benefits to health than in non-green synthetic spaces or indoors (Bowler, Buyung-Ali, *et al.*, 2010; Mitchell, 2013). A meta-analysis by Twohig-Bennett & Jones (2018) confirmed this evidence. However, some studies found no relationship between green space and health-related behaviour. For example, a study in the Netherlands by Jolanda Maas, Verheij, Spreeuwenberg, & Groenewegen, 2008, found no connection between the amount of residential green space and meeting the recommended level of physical activity. While Dalton & Jones's (2020) study showed that physical activity did not mediate the benefits of green space in reducing the risk of cardiovascular diseases.

Green space may also positively promote social cohesion and the sense of community in residential areas by increasing the opportunity for social interaction. In a study in Netherlands cities, De Vries et al. (2013) demonstrated that the quantity and quality of streetscape green space were strongly associated with an increased sense of trust and belonging and friendly relationships between people. Green space was also associated with more outdoor play, which combines physical activity and social interaction, and is essential for healthy development (McCormick, 2017). In addition to the benefits provided by relaxation and psychological restoration, scholars suggest that green spaces have a role in building psychological resilience (Dzhambov *et al.*, 2019) and strengthening and enhancing immune system functions by promoting microbial biodiversity in the environment (Rook, 2013; Kuo, 2015). In their study in Spain, Dadvand et al., 2016, found that the significant association between perceived general health and residential green space was mediated by mental health, social support and physical activity.

Scholars seem to agree that these different pathways between green space and health are likely to work interdependently and in synergy (James *et al.*, 2015; Dzhambov *et al.*, 2020). For example, living in an area with a good amount of green space may offer less exposure to air and noise pollution in this area and more psychological restoration. These areas are also more attractive for physical activity, which can prompt social interaction. Nonetheless, the evidence related to some of these mediating factors between green space and health outcomes and their interactions is not yet firmly established, and few studies have tested these mechanisms (Nieuwenhuijsen *et al.*, 2017; Twohig-Bennett and Jones, 2018).

This section sets out the relationship between residential green space and various risk factors and behaviours related to multiple physical and mental health outcomes. These different pathways also create variations in the benefits of green space for health between different people; for example, in terms of age and gender, this will be discussed more in the last part of this chapter. The following section will discuss the international evidence on the link between residential green space and different health outcomes.

3.2.2.3 Evidence of health outcomes associated with residential green space

There is considerable evidence suggesting that people living in greener areas feel healthier and have fewer health problems. Still, the evidence is mixed within different health outcomes. For example, it is strong for mortality and mental health and moderate with perceived self-reported health (van den Berg *et al.*, 2015; Twohig-Bennett and Jones, 2018).

In this section, I will discuss the literature on the benefit of green spaces, focusing on studies that used objective measures of green space. First, I will discuss the literature on mental health, well-being, and sleep, and then I will discuss physical health and mortality studies.

3.2.2.3.1 The association between urban green space with mental health, well-being, and sleep

There is strong evidence that green space is associated with better mental health, vitality and well-being (Alcock *et al.*, 2014; McEachan *et al.*, 2016; Van den Berg *et al.*, 2016; McCormick, 2017; Liu *et al.*, 2019, 2020; Song *et al.*, 2019; Zhang *et* *al.*, 2020; Nguyen *et al.*, 2021). For example, Maas et al. (2009) used data from medical records in the Netherlands and found a strong association between more residential green spaces and an increased risk of anxiety and depression. The evidence from experimental research suggests causal links between exposure to green space and benefits to mental health and cognitive outcomes (Jimenez *et al.*, 2021).

A longitudinal study in Australia measured green space by a one-mile network distance buffer around the centre of the residential areas. It demonstrated that individuals exposed to more tree canopy have better sleep quality than individuals living in areas with few trees but not grassland and shrubland (Astell-Burt and Feng, 2020a). This emphasises that not all types of green space may be associated with health benefits.

Systematic reviews have shown that the benefits of green space and mental health are stronger than physical health outcomes (Gascon *et al.*, 2015; van den Berg *et al.*, 2015). This might be related to the greater number and quality of studies on the link between green space and mental health, but it also seems convincing, given that the link between green space and mental health may be considered more direct and immediate than other health outcomes, for example, cardiovascular diseases or mortality.

However, negative results are still sometimes obtained. For example, one study in the Arab world investigated three disadvantaged areas in Morocco. They found that the ownership and interaction with potted street gardens were *positively* associated with depression. The authors suggested that people may have perceived these potted gardens as private property and, therefore, vulnerable to the unsafe environment (Afrad and Kawazoe, 2020). This shows the context-specific factors that can mediate the effect of green space on health. However, the high selection bias (70% of the sample are males without controlling for economic variables) and the small sample size in this study may introduce biases in these results.

3.2.2.3.2 Urban green space, physical health and mortality

Overall, studies and systematic reviews examining different morbidities and mortality outcomes confirm that green space benefits various non-communicable diseases. For example, a study in the Netherlands found that people surrounded by more green space than average have lower odds for twelve different chronic morbidities: coronary heart disease, musculoskeletal problems, depression, anxiety disorder, asthma and chronic obstructive pulmonary disease, migraine, vertigo, and diabetes mellitus (Maas et al., 2009).

Systematic reviews and meta-analyses found that residential green space was associated with reduced incidence and risk of cardiometabolic and cardiovascular conditions (Brown *et al.*, 2016; Twohig-Bennett and Jones, 2018; Dalton and Jones, 2020; Nguyen *et al.*, 2021). In their prospective cohort study in the UK, Dalton and Jones (2020) found that participants living in areas with the greenest quartile had 7% less risk of cardiovascular disease than the other areas. This echoes a finding from another study in the UK by Mitchell & Popham, 2008, which found that living in the least green areas was associated with a higher risk of circulatory disease, adjusting for demographic, socioeconomic and area deprivation. Green space was also negatively related to many other non-communicable diseases, such as stroke (Twohig-Bennett and Jones, 2018).

Systematic reviews demonstrated consistent and robust evidence on the link between green space with reduced risk of all-cause and cardiovascular mortality for adults and older people (Fong et al., 2018; Gascon et al., 2016; Twohig-Bennett & Jones, 2018; van den Berg et al., 2015; Yuan, Huang, Lin, Zhu, & Zhu, 2021). A meta-analysis of nine longitudinal cohort studies found a reduced risk of all-cause mortality with the increase in the amount of green space in 500 meters or less around individuals' homes (Rojas-Rueda *et al.*, 2019). The studies used in this meta-analysis were from the USA, Switzerland, China, Spain, Australia, and Italy. All these studies adjusted for individual-level characteristics and other environmental variables such as air pollution and road distance.

Another risk factor (not mentioned in the previous section) strongly related to many non-communicable conditions is obesity. A systematic review of fifty-seven studies found that more green space (measured by NDVI) was negatively associated with overweight and obesity (Luo *et al.*, 2020). However, the heterogeneity in the included studies in the meta-analysis was high, which might impact the validity of these findings. They could not detect the source of the heterogeneity between studies because of the small number of studies included which did not allow for conducting a meta-regression.

In the Arab World, there has been only one population-level study about the link between green space and health. A multi-level study of 3546 individuals living in 50 areas in Cairo, Egypt, investigated obesity in 2007 (measured by BMI) with different measures of the availability of green space. Green space was measured by the number of small gardens, public gardens, and sports clubs within the residential area and the percentage of green spaces classified as public gardens in the residential areas. They found that none of the green space measures they used had a significant relationship with obesity, despite the high variation between neighbourhoods in BMI (Mowafi *et al.*, 2012). However, their measurement of green space was restricted to gardens and sports clubs and did not include other types of green spaces, such as street trees and crop trees.

3.2.2.4 Issues related to the scientific evidence linking urban green space and health outcomes

Although some of the effects mentioned above have been proven via experimental studies, there remain limitations in the evidence base and substantial variation between studies for both presence and magnitude of effects of urban green space on health outcomes (Ward Thompson *et al.*, 2012; Markevych *et al.*, 2017). As reported by most systematic reviews, the main reasons were the poor quality of studies and methodological variations between them (van den Berg *et al.*, 2015; Twohig-Bennett and Jones, 2018; Luo *et al.*, 2020). There were many dimensions of the variability between studies. The main one was how green space and exposure to it were measured (Labib, Lindley and Huck, 2019; Jimenez *et al.*, 2021), as discussed in section 3.2.2.1. It is a problem inherent in research studying health and place.

Another aspect that prevents strong evidence from being established is related to differences in the context-specific local and regional characteristics of studies, as discussed in the previous chapters. These play an important role in determining the relationship between green space and health and are usually not accounted for. For example, a study by Mason, Pearce, & Cummins (2020) found an interaction effect between the number of urban green spaces and the number of local physical activity facilities in their relationship with obesity. This clearly indicates that different components of the physical environment most probably work in combination. Other environmental features are the cultural, political, and climatic aspects, which are important factors influencing the benefits of green space on health and the different mediators between them. The gap in the evidence for a relationship between green space and health in less-developed countries, especially in the Arab World, is problematic for representative and generalisable evidence (Rojas-Rueda *et al.*, 2019; Chiabai *et al.*, 2020; Shuvo *et al.*, 2020). This thesis contributes to the evidence by investigating the link between urban green space and health in the oPt.

The quality and type of green space may be important determinants of whether green space is conducive to health benefits or not through the different pathways, which are usually not taken into consideration in research studies. For example, some green spaces, such as parks and good-quality green pathways, may be suitable for physical activity, but non-walkable, abandoned, or unsafe green spaces might not be. The same applies to the suitability of green space to promote social interaction between residents. Green spaces' quality, attractiveness and safety are integral to how much they are beneficial to health (Markevych *et al.*, 2017; Nguyen *et al.*, 2021). Moreover, as mentioned earlier, what type of vegetation constitutes the green spaces is also important (Hartig *et al.*, 2014; Nguyen *et al.*, 2021); for example, large trees do not have the same properties as small shrubs or grasslands. Large trees have better air-purifying and cooling capacity, and these kinds of green spaces seem to operate those pathways more effectively (Zupancic, Westmacott and Bulthuis, 2015). For example, Armson, Stringer, & Ennos(2012) found that shades and evaporation from areas with large trees provide more relief from heat stress in urban settings than in grasslands.

3.2.2.5 Summary of the section

Several intertwined pathways exist between more exposure to green space and health benefits. These pathways can be classified into three themes: capacity restoration, mitigation of environmental harms and building capacities. Overall, the evidence has accumulated in the past two decades that green space benefits urban dwellers' physical and mental health and well-being. And that individuals with more exposure to green space have a lower risk of mortality than individuals with less exposure. Several issues in green space health research impede conclusive evidence, such as varying outcome/exposure measures and the scarcity of studies from developing countries.

Like all the contextual factors, the benefits of green space and the harms of disadvantaged contexts may not be universal and can interact with inhabitants' characteristics in influencing their health. The following section will discuss the interaction between the place-based features of interest in this research and personal demographic and socioeconomic characteristics, as it is one of the objectives of this thesis.

3.2.3 The interaction between environmental and personal characteristics

As discussed in chapter two, individual and contextual factors are likely to interact in their association with health outcomes. Despite this, few studies have explored these interactions (Stafford *et al.*, 2005; Roe *et al.*, 2013; van den Berg *et al.*, 2015; Gascon *et al.*, 2016). Although the area's health effects are generally small, it also suggests that for some population groups, health effects might be large (Deryugina & Molitor, 2021; Pearce, Richardson, Mitchell, & Shortt, 2010).

The experimental and observational studies that examined the interaction between individual-level and place-based characteristics suggest that place-based characteristics interact with age, sex, socioeconomic status, and racial/ethnic background in their association with health outcomes. In this section, I will discuss all these personal characteristics in their interaction with area-level disadvantage and residential green space, except race/ethnicity, because it is irrelevant to the research area of this thesis.

3.2.3.1 The interaction between the area characteristics with age and sex in their relationship with health

Several studies indicated that living in disadvantaged areas does not have the same impact on health for individuals of different ages and does not have the same impact on males and females. The presence, size, and direction of the place-based effects differed between these population groups.

Studies based on the Moving to Opportunity scheme demonstrated that the impacts of moving to advantaged areas from disadvantaged areas differed between females and males and between age groups. Sometimes the intervention had opposite effects on health outcomes for different groups. For example, Kling et al.(2007) found that moving to an advantaged area harmed young males' physical health (self-reported health, asthma attack in the past year, obesity and non-sport injury in the past year). In contrast, it positively affected young females and did not affect adults in these outcomes. The authors suggested that these differences might be related to individual and social differences. A qualitative study on a sample of the participants in the Moving to Opportunity program concluded that sex differences are related to quotidian routines, influences from peers, and the strategies individuals use to navigate through the environment and conform with the social norms, which might favour young females over males (Clampet-Lundquist *et al.*, 2011).

Systematic reviews identified stronger associations between area disadvantage and mental health problems for older people (Julien *et al.*, 2012) and young children (Spencer, Blackburn and Read, 2015; Visser *et al.*, 2021) compared to other age groups. The differential effects of area disadvantage by age might be related to the dose-response of the exposure to area disadvantage, whereby older people and children are more likely to spend more time in their local neighbourhood areas. Children are also different from adults in their developmental status, making them more susceptible to environmental exposures (Galster, 2012).

Studies also found a differential impact of area disadvantage between adult males and females. For example, a population-based cohort study in England compared individuals (age 40 and above) living in socioeconomically disadvantaged areas with those living in non-disadvantaged areas (Remes *et al.*, 2017). The authors found that females living in disadvantaged areas had a 63% higher risk of developing generalised anxiety disorders compared to those living in advantaged areas but no significant difference in risk for males. However, the sample was not representative of the whole population of England as a higher proportion of respondents (84%) were in the least deprived group, and findings might not be generalisable to individuals living in highly disadvantaged areas.

Of the few studies in the Arab World, a multi-level study in Aleppo, Syria, investigated self-rated health with the area's socioeconomic conditions and formality status in 2004 (accounting for individual-level characteristics). Formality status was described as an area belonging to formal or informal planning schemes. Substandard housing structures characterise informal areas with poor quality and basic infrastructure (like slums and refugee camps). Self-rated health was measured by a five-point Likert scale from excellent to very bad, answering the question, "in general, how do you describe your overall health?". They measured area-level socioeconomic conditions by five aggregated measures of individual-level variables: percentage of illiterate; percentage of unemployed, average household wealth (measured by household assets); percentage of housing density; and percentage of people with no car in the areas. The authors found only one area-level socioeconomic variable negatively associated with self-rated health, the average number of household items owned, only for females. They also found that females in informal neighbourhoods have more likelihood of better subjective rated health than females from formal settings. Since area disadvantage is closely related to informality status, they explained (the seemingly strange result) that informality status measured aspects that were not explained by the area disadvantage and had positive impacts on females' health (Ahmad *et al.*, 2013). This study might highlight the importance of the local context, but it might be affected by over-adjusting relatively similar area-level variables.

Bell, 2016, argued that females might be more vulnerable to area-level disadvantage because they are more likely to experience environmental burdens and are less likely to control decisions related to the environment. A study from Australia found that females benefit more from area advantage, safety and social capital than males (Kavanagh *et al.*, 2006). However, other studies found no deferential effects of living in a disadvantaged area between males and females (Hamad *et al.*, 2020); or that area disadvantage was more harmful to males than females. For example, Meijer et al. (2012)'s meta-regression analysis found that the effects of area-level disadvantage were higher on all-cause mortality for males than for females.

Several reviews on green space also stated that its association with health outcomes could depend on individuals' demographic and socioeconomic characteristics (Lachowycz and Jones, 2011; Markevych *et al.*, 2017; Twohig-Bennett and Jones, 2018; Bolte, Nanninga and Dandolo, 2019). At the same time, and like area socioeconomic disadvantage, these reviews stated no consistent pattern of these interactions. For example, some studies found green space to be more beneficial for females compared to males for obesity and overweight (Astell-Burt, Feng and Kolt, 2014; Sander, Ghosh and Hodson, 2017), and stress (measured by mean cortisol levels) (Roe *et al.*, 2013). On the other hand, other studies found that green space is more beneficial to males than females, for example, with mortality outcomes such as cardiovascular, respiratory disease and all-cause mortality (Richardson and Mitchell, 2010; Crouse *et al.*, 2017).

The inconstancy is also echoed for age. For example, some studies found that green space was more beneficial to young adults with obesity and overweight (Sander, Ghosh and Hodson, 2017) and depression (Sarkar, Webster and Gallacher, 2018). Other studies found that green space was more beneficial to children younger than 12 years old for anxiety and depression (Maas *et al.*, 2009). While Crouse et al. (2017) found that green space was more beneficial for people aged between 35-74 compared to children and older people. In contrast to other studies, which found that the elderly population benefits more from green space. For example, in relation to self-reported health, measured by three indicators: the number of symptoms in the last two weeks, perceived general health, and psychological conditions via the General Health Questionnaire (GHQ) (de Vries *et al.*, 2003).

Other studies and reviews found no difference between males/females and age groups in the benefits of green space. For example, concerning mental health (Van den Berg *et al.*, 2016), diabetes (Thomas Astell-Burt, Feng and Kolt, 2014), self-rated general health (Hong *et al.*, 2021), and sleep quality (Shin *et al.*, 2020).

3.2.3.1.1 Area characteristics and individual socioeconomic status

The evidence of an interaction between individual-level socioeconomic status with area characteristics in their association with health outcomes is also inconsistent. For example, experimental studies suggested that place-based effects were more important for lower socioeconomic positions (Chetty, Hendren and Katz, 2016). Similarly, Finch et al. (2010) found that the positive association between living in disadvantaged areas and stress (allostatic load) was stronger in people with lower education.

Similarly, some studies suggested that green space was more beneficial for individuals with low socioeconomic status, for example, concerning perceived general health (Maas *et al.*, 2006); depression and anxiety (Maas *et al.*, 2009; McEachan *et al.*, 2016); adiposity (Sarkar, 2017); and mortality (Mitchell and Popham, 2008). These studies suggested that people with poor socioeconomic conditions may suffer from greater health problems than well-off individuals, partly because their environment or lifestyles are less conducive to health (more pollution and stress), and they have less access to resources either by proximity or financial constraints; thus, green space may offer more immediate and cheaper resources, therefore more health benefits to them.

On the other hand, other studies found that green space benefits individuals with high socioeconomic status to a greater extent. For example, studies found that the all-cause mortality of individuals with higher socioeconomic positions and higher education benefits the most from green space compared to lower socioeconomic status and less educated people (Crouse *et al.*, 2017; Pun, Manjourides and Suh, 2018). These studies suggested that wealthier people have more 'real' leisure time to enjoy these spaces than less affluent populations and better quality of green space. In contrast, socioeconomically disadvantaged individuals are more likely to have less safe or low-quality green spaces, which reduces their use and benefits. Other studies found no difference between socioeconomic groups. For example, a study in Spain found that perceived general mental and physical health are associated with green space consistently in all socioeconomic groups (Triguero-Mas *et al.*, 2015).

3.2.3.1.2 Possible explanations for the inconsistent evidence of interaction effects

The inconsistency of the evidence in the interaction effects between urban green space and areas disadvantaged with personal characteristics in their relationship with health is probably related to the multiple and intertwined mediating factors between these environmental factors and health outcomes. Individual-level characteristics such as age, sex and socioeconomic status are proxies for many interrelated factors that might differ depending on the outcome under study and how they interact. For example, the review by Lee & Maheswaran (2011) showed that using green space for physical activity depended on the characteristics of the users, where males and younger people tend to use green space for physical activity more than females and older people. The authors also stated that green space use highly depends on personal motivation and barriers such as health status, lack of time, and perceived safety. Whereas, Dadvand et al.(2016) study based in Barcelona found that males and adults under 65 benefits more from the social support and mental health restoration that green space offers than females and individuals older than 65.

Other reasons for the inconsistency of evidence of interaction effects are the dependence of this relationship on the context and the broader environmental factors (discussed in the previous sections) and the common issues of heterogeneity between studies in the designs, units of analysis and measurements of the environmental features and the socioeconomic attributes.

3.3 Conclusion

In this chapter, I put the thesis objectives in the context of international evidence. I reviewed the empirical evidence related to area disadvantage and green space with health. I demonstrated that area disadvantage and green space are important determinants of health; however, the evidence is still inconsistent and not representative worldwide. One of the main reasons for the inconsistency of the evidence is largely due to varying methodologies between studies and inconsistent definitions and measurements for these contextual features.

In this thesis, I will use political indicators for the area's disadvantage, namely, political land classification and refugee camps. In this chapter, I discussed those politics and politically created disadvantages that greatly influence health via multiple channels, which is understudied, especially in the developing world. Similarly, the literature has shown no specific accepted definition of greenspace to be more or less important for health. Thus, in this thesis, I will adopt the WHO definition of urban green space: "all public and private land that is covered by any kind of vegetation of any size and function" (WHO, 2017). This includes various typologies such as forests, public parks, public and domestic gardens, playgrounds, agricultural and farmlands, cemeteries, and street trees. To view a detailed list of typologies of green space, see Swanwick, Dunnett, & Woolley (2003). This chapter also showed the importance of differentiating between green space typologies, as not all have the same beneficial impact on health.

In this chapter, I also reviewed the evidence related to the interaction between area-level factors and individual-level characteristics (age, sex, and socioeconomic status). I demonstrated that many studies found evidence of an interaction effect; however, there was no consistent interaction pattern, which requires further investigation. Many studies had selection bias, and their samples were not representative; ensuring a representative sample is important.

Context is an essential factor affecting the presence and strength of association between health and place-based features. Overall, evidence is scarce in the developing world, particularly in Arab countries. The evidence dominantly in the developed world is not generalisable to specific populations such as the oPt and the Arab countries, and local investigations are warranted. Achieving this thesis's objectives will contribute to the international evidence on the relationship between health and places in this understudied context. These are the main pillars of and arguments for the thesis.

The following chapter will provide an overview of the oPt and the twin cities of Ramallah and Albireh, the research area in this thesis.

Chapter four: Contextual background

4.1 Introduction

This chapter aims to provide a contextual background about the occupied Palestinian territory and the twin cities of Ramallah and Albireh. The body of this chapter is divided into two sections. In the first section, I will briefly describe the oPt, covering geographical features and chronological snapshots of the significant historical and political events that this region had gone through. This information is necessary to understand the Palestinian context because it describes the origins and turning points that shaped the social, environmental, and political conditions in the oPt today. The section continues by presenting the demographic and environmental conditions in the oPt while focusing on specific aspects related to this research. It ends with a summary of the main health indicators.

The second part of this chapter will provide an overview of the twin cities of Ramallah and Albireh, the urban environment of focus in this thesis. Here, I will present some geographical and historical information about the twin cities. I will also describe the political, environmental, demographic, socioeconomic and health characteristics of the twin cities of Ramallah and Albireh.

4.2 The occupied Palestinian territory

4.2.1 Geographical, historical, and political background

Before modern times, 'Palestine' referred to the stretch of land at the eastern border of the Mediterranean Sea, located between Syria in the north, Egypt in the West, and Arabia in the East. Such strategic location at the crossroads between major ancient world civilisations exposed this region to a wealth of historical and cultural events and has been marked by constant unrest, conflict, and conquests. The region's religious importance for Judaism, Christianity, and Islam added to its global interest and desire to conquer and control. From antiquity and throughout recorded history, several groups have ruled the region. The name 'Palestu' was argued as the region's first name traced to ancient Egyptian and Assyrian scriptures around the 12th century BCE. The last name, Palestine, began to be used in the ancient Greek era around 500 BCE and was officially used by their successors, the Romans (Lewis, 1980).

4.2.1.1 The British control of Palestine

At the beginning of the twentieth century and following the defeat of the Turkish (Ottoman) empire by the League of Nations in World War I, 'historic' Palestine came under British rule (at the end of 1917). The San Remo conference in 1920 granted Britain the formal administration over Palestine, named "the Mandate for Palestine", which was enforced in 1923 (Lewis, 1980; Rempel, 2006). Palestine became recognised internationally with defined geographical boundaries (of an area of 27000 km^2), as shown in Figure 4-1 (Ginat, 2018; "Mandatory Palestine," 2015).

Figure 4-1: The map of Palestine in the British Mandate 1946 (base map obtained from ("Mandatory Palestine," 2015) Creative Commons Attribution-Non-commerciaShareAlike 4.0)

Large demographic and political changes occurred during the British Mandate of Palestine. On the one hand, the Mandate terms incorporated the Balfour Declaration (1917) and supported the Zionist's ambitions for a "national Jewish home" in Palestine (see: Britannica, 2020). Accordingly, the British policies facilitated Jewish migration to colonise Palestine and supported them with the means to establish an independent Jewish nation (Rempel, 2006; Khalidi, 2007, 2017). Between 1922 and 1945, the percentage of the Jewish population in Mandatory Palestine increased about tenfold, approximately from 11 to 33 per cent of the total population (Ginat, 2018).

On the other hand, the Palestinian Arab population, with the demographic majority in Mandate Palestine, were denied political authority and representation. They were not even mentioned as a nation in the British Mandate terms. They faced constant oppression and displacement policies impeding their demands for autonomy and independence (Khalidi, 2007; Yvonne *et al.*, 2020), ultimately creating a structural imbalance favouring and empowering the Zionists in Palestine. The tension gradually culminated, leading to the 'Palestinian revolt' between 1936-1939 that the British administration severely crushed with massive use of force. About ten per cent of the Palestinian Arab men were killed, wounded, or imprisoned. During this period, the oppression further increased, and so did the power imbalance against Palestinian Arabs (Khalidi, 2017).

4.2.1.2 The Palestinian Catastrophe

On the 29th of November 1947, the United Nations General Assembly announced a 'Partition Plan' that divided Palestine into a Jewish state (56%) and an Arab state (44%). The Palestinians rejected the plan for many reasons, mainly that half of the population in the proposed Jewish state were Palestinian Arabs, who owned 90% of the land. Furthermore, the plan did not recognise Palestinians as an independent nation but was instead controlled by other external Arab forces. A civil war started soon after, where the Zionist militants had the upper hand regarding fighters, resources, weapons, organisation, and international support, especially from the USA and the Soviet Union, who were the first to support the partition plan. The

Zionists started conquering Palestinian cities and villages in the parts designated to them by the Partition Plan and driving out their inhabitants by force (Rempel, 2006; Khalidi, 2007).

On the 14th of May 1948, the British withdrew their sovereignty over Palestine, and on that day, the state of Israel was established. In the following days, the Arab neighbouring states (Jordan, Lebanon, Syria, and Iraq) intervened in Palestine. A war started between the Arab armies and the newly established state of Israel, referred to as the "1948 Arab-Israeli War". The Arab armies were divided, disorganised, unprepared, and outnumbered. The result was their defeat and the destruction of Arab Palestine. After multiple ceasefire agreements, the 1948 Arab-Israeli war ended in March 1949 (Khalidi, 2020).

About 78% of the total area of Mandatory Palestine became within the borders of the newly established state of Israel, more than what was set by the partition plan by 22%. The remaining land constituted the West Bank (and East Jerusalem) which was rendered under Jordanian rule, and the Gaza strip, which was rendered under Egyptian rule (Figure 4-2). The area between the Arab and Israeli regions was the Armistice line, commonly called the 'Green line'. About 85% of the Arab Palestinians living in the area now behind the 'Green line' within the state of Israel were cleansed (Rempel, 2006; Khalidi, 2007; Yvonne *et al.*, 2020).

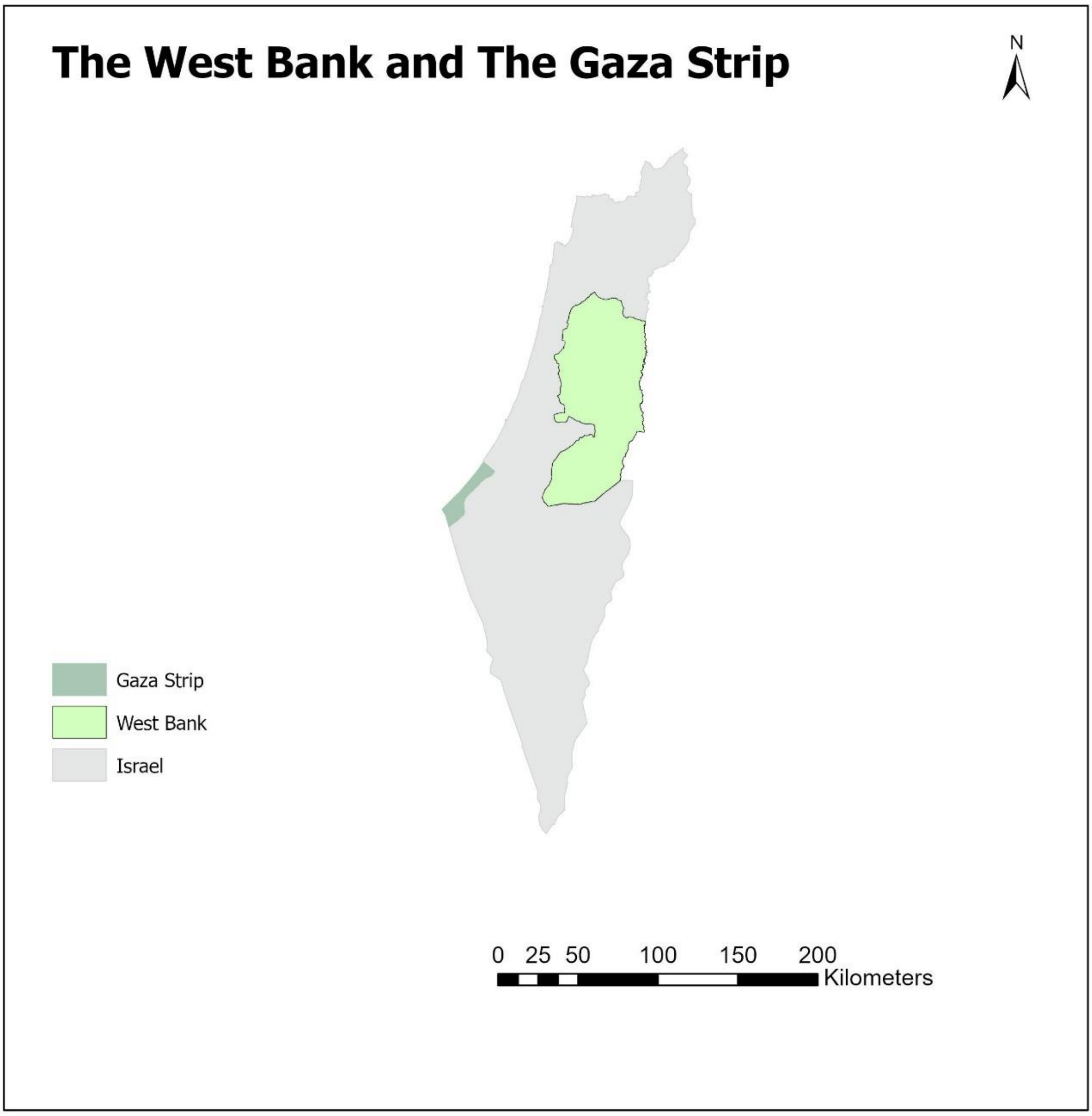

Figure 4-2: Map of the West Bank and the Gaza Strip (data obtained from Hijmans (2015) and OCHA (2016) (Creative Commons Attribution- Non-commercial-ShareAlike 4.0))

For Palestinians, the years between 1947-1949 marked what they call the "Catastrophe" (or "Al-Nakba" in Arabic). Predicated on decades of British oppression, they witnessed the collapse of the urban society and the breakdown of their control over their lives. They lost their homes, lands, and dignity - a trauma that still haunts the Palestinians to this day. Out of fear of the Zionist's violence, approximately 750,000 people (more than half of the Palestinian population) fled their homes and lands and became refugees. Israel closed its borders, and no refugee was ever allowed to return (Khalidi, 2007; Morris, 2012; Shalhoub-

Kevorkian, 2015). Most Palestinian refugees fled to the West Bank and the Gaza Strip, and others crossed the borders to the neighbouring countries.

4.2.1.3 The Setback

The creation of the state of Israel was not the end goal for Israel. On the 5th of June 1967, Israel occupied the West Bank (including East Jerusalem) and the Gaza strip regions (Figure 4-2), in a military action referred to as the Six Days War. Since then, the name occupied Palestinian territory (oPt) has been attached to this area and used by the United Nations and other international organisations. Also, in 1967, Israel occupied two-thirds of the Golan Heights regions, recognised internationally as occupied Syrian land. For the Palestinians, this period marked "The Setback" ('Alnaksa' in Arabic). Approximately 400 thousand Palestinians were displaced from their lands, including about 120000 refugees displaced for the second time (Rempel, 2006; Buttu, 2015).

Soon after the 1967 war, Israel started colonising the oPt with extensive land expropriation and the building of illegal Jewish settlements[8] (Cohen and Gordon, 2018; Fahoum and Abuelaish, 2019). In addition, Palestinians living under Israeli military occupation experienced various sorts of oppression and injustices, human rights violations, structural discrimination and policies of forcible transfers and segregation (Yvonne *et al.*, 2020). With several violent assaults against the Palestinians, these conditions culminated in the start of a Palestinian revolt referred to as the 'Palestinian Uprising' ("Intifada" in Arabic) in 1987. The uprising against Israeli rule continued till 1996, following the Oslo peace agreements in 1993 and 1995 between the Palestinian Liberation Organization (PLO) and the state of Israel. These agreements further subjugated the Palestinians. They are significant because they created particular political and planning environments that this research explores.

[8] The settlements within the borders of the Palestinian territory of the 1949 Green line are illegal by the international humanitarian law according to the 4th Geneva Convention.

4.2.1.4 The Oslo Accords and the political land classification

After secret talks, the PLO and Israel signed two peace agreements to end the 'Palestinian Uprising'. The first was the 'Oslo I Accord' in 1993, signed in Washington DC, USA. The second agreement was in September 1995, signed in Egypt and called 'the Oslo II Accord'. The Palestinian Authority (PA) was created as an interim administrative branch of the PLO to rule the Palestinian population. These agreements initially granted the PA an ambiguous form of sovereignty over small parts of the West Bank and Gaza Strip regions, in main Palestinian cities, albeit subject to overall Israeli control (Rempel, 2006; Erakat, 2020).

Many Palestinians opposed these agreements as they did not address their aspirations of self-determination, formalised the loss of lands and water resources and fragmented the Palestinians socially and spatially (Pundak, 2001; Said, 2012; Heinrich Böll Stiftung, 2013; Yvonne *et al.*, 2020). On the ground, the agreements officially fragmented the West Bank into three political classifications (Figure 4-3): 'Area A' covers 17.7% of the West Bank area and includes large urban centres, in which the PA has total administrative and security control. 'Area B' covers 18.3% of the West Bank area, where the PA has the civil administration but remains under Israeli security control. 'Area C' covers 61.1% of the West Bank, over which Israel has full civil authority, administration and security power (B'tselem, 2019; Jad & Hilal, 2011; Khamaisi, 2018). The remaining 2.9% had had other classifications such as natural reserves.

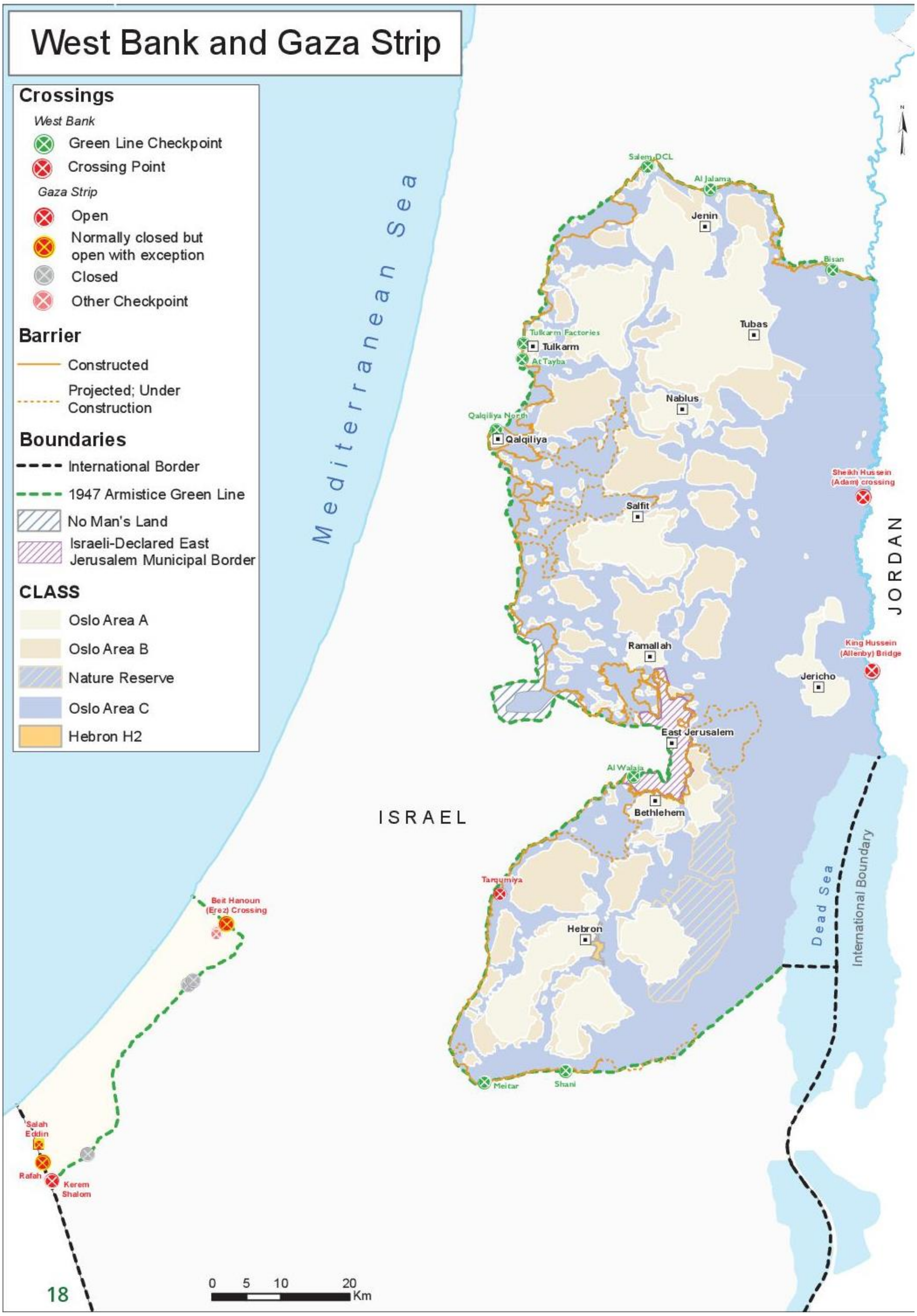

Figure 4-3: The oPt boundaries and land classification obtained from the 2018 WHO report with permission from the World Health Organization, Regional Office for the Eastern Mediterranean Region (WHO. EMRO, 2018)

The PA administration in the enclaves classified as 'Area A' and 'Area B' was incomplete because Israeli forces could enter these areas and control the borders, natural resources and the sky above them (Harker, 2017). All these classifications, and many of the terms of the Oslo agreements, were meant to be temporary until a future "final solution". Other persistent issues, such as Israeli settlements in the oPt, borders, Jerusalem, and the return of refugees, were delayed until further negotiations. The Palestinian aim was that implementing the Oslo agreements would lead to solving these issues and reaching the "two-state solution", thus, the independence of the "State of Palestine" on the borders of 1967. For example, the PA was supposed to take complete control of 'Area C' by 1999. However, that did not align with Israeli plans and objectives, backed by American support. No agreement about any of these issues has been reached to this day. ‘Area C’ remains purportedly within the territory of the State of Israel, despite the illegitimacy of the Israeli occupation according to international law (Heinrich Böll Stiftung, 2013; Bier, 2017; Khalidi, 2020).

4.2.1.5 The second Palestinian uprising

Following the Oslo peace agreements, the oPt witnessed a short period of relative political and economic stability. However, there were growing tensions, violent incidents, and distrust in the peace process on the Palestinian and Israeli sides. On the one hand, Israel did not respect the agreements. It continued confiscating lands and building illegal settlements in the oPt, undermining the two-state solution and restricting the freedom of movement of Palestinians. On the other hand, Israel accused the Palestinians of not committing to its security (Rempel, 2006; Stockmarr, 2012).

In July 2000, political and violent events provoked further unrest, resulting in the 'Second Palestinian Uprising', which lasted till around 2004. This period was critical, with grave consequences for Palestinian cities, localities, and villages that last to this day. One of these consequences was the segregation system intensified via three channels: building the separation wall around the Palestinian regions and localities, separating them from Israeli areas and each other; the deployment of hundreds of military checkpoints throughout the road networks; and imposing further political land classifications and subdivisions (Beauchamp, 2018; WHO. EMRO, 2018; Amnesty International, 2020; UNEP, 2020). The results were more loss of lands, more fragmentation of the Palestinian communities and more restrictions on the freedom of movement for individuals and goods. These largely hindered the already weak economy and development, and in many ways, they disrupted the livelihood of the Palestinian population (Parsons and Salter, 2008; Isaac *et al.*, 2015; UNEP, 2020).

In summary, the Oslo peace process and the two states' solution collapsed and failed, despite some initiatives, summits, and negotiations in the following years (see: Heinrich Böll Stiftung, 2013). The conditions enforced by the Oslo agreements and the second uprising, like the political land classifications and the separation wall, became the status quo in the oPt today.

The following section provides a glimpse of the current conditions in the oPt and the main challenges. It will focus on environmental aspects and the two disadvantaged contexts of interest in this thesis: the refugee camps and the political land classifications.

4.2.2 The current conditions in the oPt

The oPt ranks as a lower middle-income country. In 2017, the estimated population number in the oPt was roughly five million; 60% live in the West Bank. The population of the oPt was relatively young, with about 40% of the population under 14 years old (PCBS, 2018). In 2016, about 77% of the Palestinian people lived in urban areas. Reports showed that the size of the Palestinian urban population had almost tripled since 1995, with an estimated urban population growth rate of 3.2%. In contrast, the rate globally was 1.7% in the same period (MoLG, 2016).

The oPt shares some commonalities with low-middle-income countries worldwide regarding the threats and challenges at different environmental levels. There are, for example, challenges related to population growth, urbanisation and limited resources (Kasperson and Kasperson, 2022). The political conditions and the Israeli military occupation are specific to the oPt, as discussed in the previous section. These conditions magnify environmental challenges and create other unique adversities.

Evidence has shown that the Israeli military occupation has negatively impacted Palestinians' daily living and quality of life in various domains, such as safety, well-being, mobility, and economic life (Roy, 1999; Rempel, 2006; Giacaman *et al.*, 2011; Alkhatib, 2018). For example, Israeli completely controls the external and internal borders (between different regions) of the oPt. The constant closures of these borders hampered the movement of labour and goods and significantly impacted the Palestinian economy.

There are also severe environmental challenges related to the political conditions in the oPt. These conditions include the following:

- Palestinian urban expansion and development are restricted to 50 highly dense urban enclaves (areas politically classified as 'Area A' and 'Area B').

- Palestinians lack control over essential natural resources creating severe shortages in the oPt, such as in water resources and lands for agriculture and development (Philip Issa, 2012; Isaac *et al.*, 2015; Yvonne *et al.*, 2020; Salem, Yihdego and Hamaaziz Muhammed, 2021).

- Geographic and political fragmentation in the oPt and the limited executive powers of the PA complicate and impede adequate urban and environmental planning, governance, assessment, and management. It is one of the main reasons that the planning and environmental regulations in the oPt are ineffective and unable to protect the people and the environment (UN-Habitat, 2014; UNEP, 2020; Rosenthal, 2021).

All these factors, coupled with accelerated population growth and urban expansion, are translated into increasing trends of interrelated environmental problems that are expected to worsen in the future. These problems include:

- an increase in crowded and informal urban areas and unsustainable urban growth (Helu, 2012);
- rising amounts of air, water, soil and noise pollution (von Schneidemesser *et al.*, 2010; MoLG, 2016; Heo *et al.*, 2017);
- land degradation and loss of greenery and biodiversity (Nazer and Hammad, 2009; MoLG, 2016);
- inadequate and ageing urban infrastructure to support the population (UNEP, 2020);
- inefficient wastewater and solid waste management systems (Stamatopoulou-Robbins, 2021);
- more frequent heatwaves and draughts (UNEP, 2020).

These environmental problems are particularly acute in the Gaza Strip, which the United Nations stated would become inhabitable by 2020 (United Nations, 2012).

The list above is not exhaustive. Other environmental and social problems exist in the oPt and to variable degrees related to the political conditions. The elements of interest in this research are the refugee camps and the political land classification 'Area C'. Previously, I discussed the political and historical origins of these disadvantaged contexts. In the following text, I will describe what it means to live in these contexts and some of the current conditions specific to them that are plausibly harmful to health.

4.2.2.1 Refugee camps

The Palestinian refugee situation is one of the most protracted refugee situations in the world. In 2017, with the fourth generation, Palestinian refugees constituted about 66% of the global Palestinian population, around 8.1 million people (Yvonne *et al.*, 2020). In the oPt, registered refugees and their descendants living inside and outside the refugee camps counted more than 2 million, about 41% of the population (PCBS, 2019b). Two-thirds of the refugees and their descendants left refugee camps and settled in cities and villages across the West Bank and the Gaza Strip. In many towns and villages in the oPt, including the twin cities of Ramallah and Albireh, refugees constituted more than half the total population (Rempel, 2006). Once individuals leave refugee camps, they still carry the label of refugee during their life course. For different political, social, and socioeconomic reasons, one-third of refugees continue to live in refugee camps today.

Refugee camps in the oPt started as temporary tent camps after the ‘Palestinian Catastrophe’ in 1947-1948. They were established with the help of social and non-governmental organisations, which also helped with food, schools, and medical services for refugees. In 1949, the United Nations established an organisation supporting Palestinian refugees with humanitarian assistance called the United Nations Relief and Works Agency (UNRWA). Since then, it has provided aid to refugees in essential services such as food, health and education (MoLG, 2016; Berg, 2017). In the following years/decades, refugee camps gradually transformed into low-standard built areas; the refugees themselves built their houses with the help of the UNRWA. The structure was predominantly arbitrary and had no zoning, planning or appropriate infrastructure (UNEP, 2020).

In 2017, the West Bank had about half a million refugees living in 19 refugee camps. The Gaza Strip had about 200,000 refugees living in eight refugee camps (ANERA, 2020). Refugee camps represent the most disadvantaged socio-spatial formations within or close to Palestinian cities. With the advent of the Palestinian Authority in the 1990s, refugee camps were not integrated into the government's or the municipalities' jurisdiction or development schemes. The refugee camps' population continued to suffer from considerable structural and environmental disadvantages and the absence of governance. They are highly overcrowded with unfavourable living conditions, inadequately built infrastructure, poor housing conditions and essential services such as sanitation, water, and electricity (Taraki, 2008; Chaaban *et al.*, 2010; Helu, 2012; Miari, 2012; Jonassen *et al.*, 2018; Wardeh and Marques, 2021). They severely lack socioeconomic resources, amenities and green spaces (ANERA, 2020; UNEP, 2020). According to the Palestinian ministry of local government, in 2016, the poverty rate in refugee camps was higher than 35% (household income less than 609.8 US dollars per month), and the unemployment rate was about 45% (MoLG, 2016).

As discussed in chapter three, the combination of these harmful environmental aspects potentially harms the health and well-being of the residents of refugee camps (Hunter, 2009; Marshall, 2015; Behnke *et al.*, 2020). One of the objectives of this research is to investigate the link between living in the context of refugee camps in the twin cities of Ramallah and Albireh and health.

4.2.2.2 Political land classification 'Area C'

The land classified politically as 'Area C' (plain grey colour in Figure 4-3) is under full control of the Israeli military occupation (administration and security). It constitutes 61% of the area of the West Bank. It is primarily rural and contains most of its natural resources. About 350 thousand Palestinians resided in 'Area C' in 2017, around 10% of the population of the West Bank (Khamaisi, 2017).

'Area C' is not physically separated from other areas controlled by the Palestinians ('Area A and B'). Its borders with Jerusalem are delineated by an eight-meter-high separation wall and several military checkpoints. Within 'Area C', more than 70% of the land is designated exclusively for Israeli settlements, included within their council boundaries, and separated from the rest of ‘Area C’ by the separation wall and military checkpoints. These lands are inaccessible to Palestinians either for use, agriculture or development (UN Habitat, 2015).

Since the occupation of the West Bank in 1967, the main aim of all the Israeli governments and the civil administration was to increase the establishment of Jewish settlements and limit the expansion of Palestinian cities and villages (Stockmarr, 2012; Cohen and Gordon, 2018). This aim continued during and after the 1990's peace agreements, despite continuous Palestinian and international objections. In 2018, the Israeli settlements in 'Area C' of the West Bank numbered 130, hosting Israeli communities of about 600 thousand settlers. This number was equal to 15% of the West Bank population and 65% of the population of land politically classified as 'Area C' (Beauchamp, 2018).

Compared to 'Area A' and 'Area B', where the Palestinian Authority controls the civil administration, 'Area C' is disadvantaged on several dimensions: environmental, socioeconomic, governance, and security. The lands where Palestinians reside in 'Area C' had immense restrictions on development, planning and essential infrastructure. For example, all the developments in these areas (e.g., housing, roads, or sewage systems) required permits from Israeli authorities, which were hampered most of the time. Israeli authorities only granted permits for 2% of the 2000 applications for building permits in ' Area C' between 2009 and 2013 (Lieber, 2016). Houses built by the local population in 'Area C' or community-led developments without Israeli authorities' licenses were at risk of demolition (UN Habitat, 2015). Compared with 'Area A' and 'Area B', 'Area C' has a more restricted socioeconomic development and fewer amenities and institutions. It has the worst urban infrastructure and planning and a poorer transportation system. 'Area C' residents have poorer access to essential services such as water, food, sanitation, and good education, recreation and health services (Khamaisi, 2017; WHO. EMRO, 2018; Fahoum and Abuelaish, 2019).

Furthermore, people living in 'Area C' have higher insecurities and instabilities, such as the risk of displacement, house demolishing, and Israeli settlers' attacks. They are also highly exposed to the pathological landscape of Israeli settlements, military bases and checkpoints, and the separation wall (Parsons and Salter, 2008; Fields, 2010; Isaac *et al.*, 2015; Khamaisi, 2017, 2018).

It would be expected that the population in 'Area C' has worse health status; however, no studies have been conducted at the national or local levels to confirm this. One of the objectives of this thesis is to fill this gap and investigate the context of 'Area C' with health in the twin cities of Ramallah and Albireh. In the second part of this chapter, I will discuss the negative impact of the political land classification on the urban environment in the twin cities of Ramallah and Albireh.

4.2.3 Health in the oPt

In 2018, life expectancy at birth in the oPt was 73.9 years, and the infant mortality rate was 17.3 per 1000 live births (WHO, 2020). These figures rank the oPt in the middle compared to other countries in the region (World Bank, 2019a). Non-communicable diseases were highly prevalent and followed a rising trend in the oPt, responsible for two-thirds of the mortality (WHO. EMRO, 2018). Cardiovascular diseases, cancers and cerebrovascular diseases were the leading three causes of death and disability (WHO, 2017). Hypertension and diabetes dominated the health problems, particularly in the refugee camps (Collier and Kienzler, 2018; McNatt, 2020). The increasing trend in the prevalence of non-communicable diseases was parallel to the increase in behavioural risk factors such as low levels of physical activity, particularly among females and adolescents (Dhair and Abed, 2020; Rosenthal, 2021) and high rates of smoking and obesity (Collier and Kienzler, 2018).

Mental health was perhaps the most significant public health issue (Giacaman *et al.*, 2011). The oPt had the highest burden of mental illness in the Middle East region (WHO, 2020). An estimate reported by the WHO in 2019 concluded that one in every five individuals in the oPt has a mental disorder that requires essential intervention (WHO, 2020). Depression was the third largest cause of disability-adjusted life years (DALYs) after ischemic heart disease and neonatal disorders (IHME, 2021). Children and teenagers experience high exposures to prevalent traumatic events in the oPt, associated with chronic mental health issues (ANERA, 2020). However, the data on mental health disorders in the oPt was not very robust; it was based on the global burden of disease estimation (WHO, 2017). Studies on well-being showed that a third of the population in the oPt reported low levels of well-being (WHO, 2017), particularly among youths (Khatib and Hammoudeh, 2019).

Such trends in physical and mental health and behavioural risk factors in the oPt lie alongside deteriorating structural elements primarily related to the Israeli military occupation and, as described by the World Bank, the "grim" economic prospects (Fahoum and Abuelaish, 2019; ANERA, 2020; UNEP, 2020).

The previous section discussed the main historical, political, and current conditions shared by the wider oPt population. The following section will provide an overview describing the main characteristics of the twin cities of Ramallah and Albireh, the research area in this thesis.

4.3 The twin cities of Ramallah and Albireh

The West Bank, with an area of 5688 km^2, has 11 governates and 335 localities. In the middle of the West Bank, one of its largest governates is Ramallah and Albireh. The governate of Ramallah and Albireh has 84 localities. Among these localities are the twin cities of Ramallah and Albireh (Figure 4-4), the urban environment investigated in this thesis. Ramallah covers 18.7 km^2, and Albireh covers 22 km^2. Ramallah and Albireh are located 67 kilometres East of the Mediterranean Sea, sharing similar flora and fauna to the Mediterranean region. Their elevation is around 850 meters above sea level, their climate is hot and dry in summer and cool and wet in winter, and the average annual temperature is 16 Celsius (ARIJ, 2012a; MoLG, 2016).

In chapter one, I stated the reasons for choosing the twin cities of Ramallah and Albireh as the research area. In this section, I will provide an overview of the twin cities, their history, population, urban environment, and the health conditions of their residents.

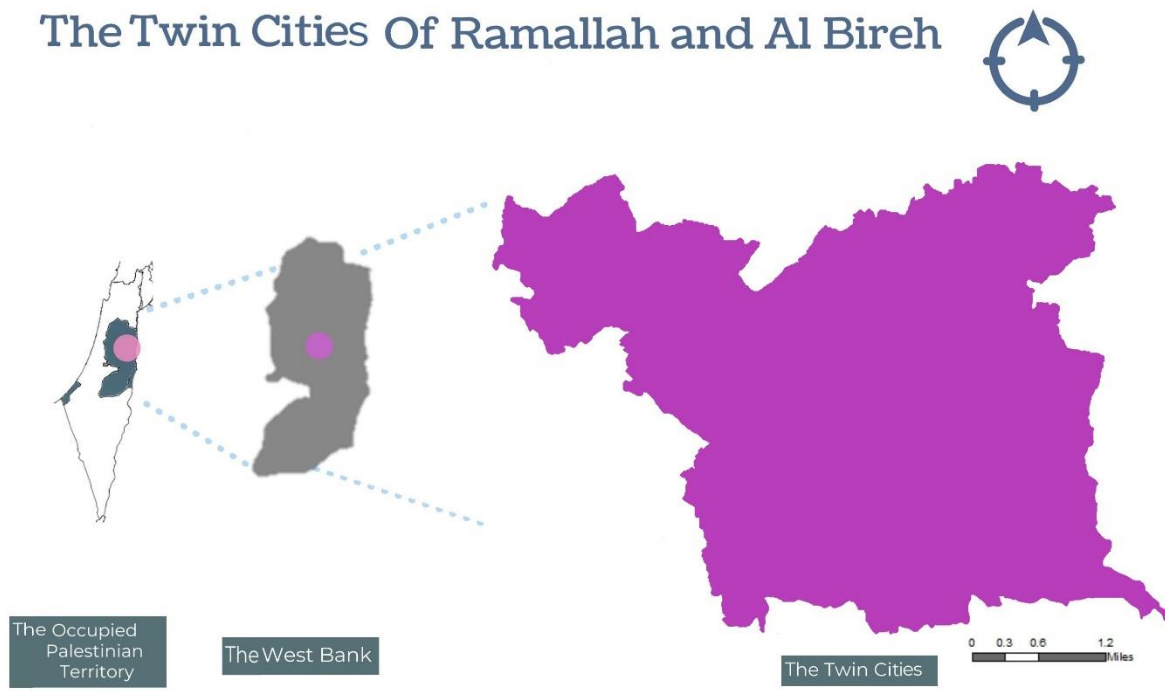

Figure 4-4: The Twin cities of Ramallah and Albireh. (Sources: Administrative boundaries obtained from the Palestinian Central Bureau of Statistics in 2018)

4.3.1 History and politics that shaped the twin cities of Ramallah and Albireh

Historically, both Ramallah and Albireh were agricultural societies. Ramallah was established in the mid-1500s as a Christian enclave. Through the 17th and 18th centuries, it grew as a farming village. In the following decades, Christian missionaries played an important role in building educational and religious establishments in Ramallah, including schools and churches. Albireh was a more ancient village mentioned in several texts in the Roman era. In the early 1900s, urban transformation emerged in Ramallah and Albireh, mainly due to the economic flourish associated with trade routes with the USA, established by locals who immigrated there. Ramallah and Albireh were established as cities during the British Mandate in Palestine (ARIJ, 2012b, 2012a; Aruri, 2015).

After the 1948 war and the influx of refugees from the land that became the state of Israel, a substantial population increase occurred in Ramallah and Albireh. They hosted refugees, mainly displaced from neighbouring regions such as Lydda and

Ramleh. Two refugee camps were established within the two cities, one is called Al Amari, and the other is Qadoora. In 1952, about two third of the population of both cities were refugees (Hilal and El-sakka, 2015). This period and the following years significantly transformed the urban environments in Ramallah and Albireh. Due to the proximity and growth of both cities, they physically merged around the 1960s while having their own municipal and administrative borders; this is why they are called "the twin cities of Ramallah and Albireh" (Najjar and Ghadban, 2015).

A turning point was after the Oslo peace agreements in the 1990s when the Palestinian Authority decided to use the twin cities of Ramallah and Albireh as a governmental headquarter and an institutional and economic seat. The twin cities became the main Palestinian service-providing and commercial space in the West Bank and the centre of governmental, non-governmental, financial, and cultural institutions. Local and international businesses flourished, including banks, companies, and hotels. These developments made the twin cities an attractive destination for internal and external migration.

External migration into the twin cities mainly consisted of Palestinians in the diaspora (returnees), who were permitted to return after the peace agreements. The prominent social and economic status and the promising opportunities provided by the twin cities of Ramallah and Albireh attracted Palestinians from all over the oPt. The twin cities became the centre of attention for the young generation who sought to settle (Taraki, 2008; Harker, 2017). Reports stated that 25.5% of the internal migration in the oPt in 1997 targeted the twin cities (Lubbad, 2007).

Consequently, rapid population growth and extensive horizontal and vertical urban expansion followed (Hilal and El-sakka, 2015; Najjar and Ghadban, 2015). The twin cities also became a daily destination for people across the West Bank and Jerusalem to work, trade, study, and socialise. In 2015, the twin cities were estimated to have about 150 to 250 thousand daily visitors (Muhsen, 2017).

However, like other cities in the oPt, the urban environment in the twin cities of Ramallah and Albireh had been heavily affected by the political conditions and the Israeli military occupation (discussed earlier in this chapter). Notably, as seen in Figure 4-5, the political land classification has had an influence. The eastern, southern, and north-western parts of the twin cities are controlled and administered by Israeli authorities ('Area C'). The political land classification dramatically impacted the twin cities' urban environment and will be discussed, among other aspects, in the following section.

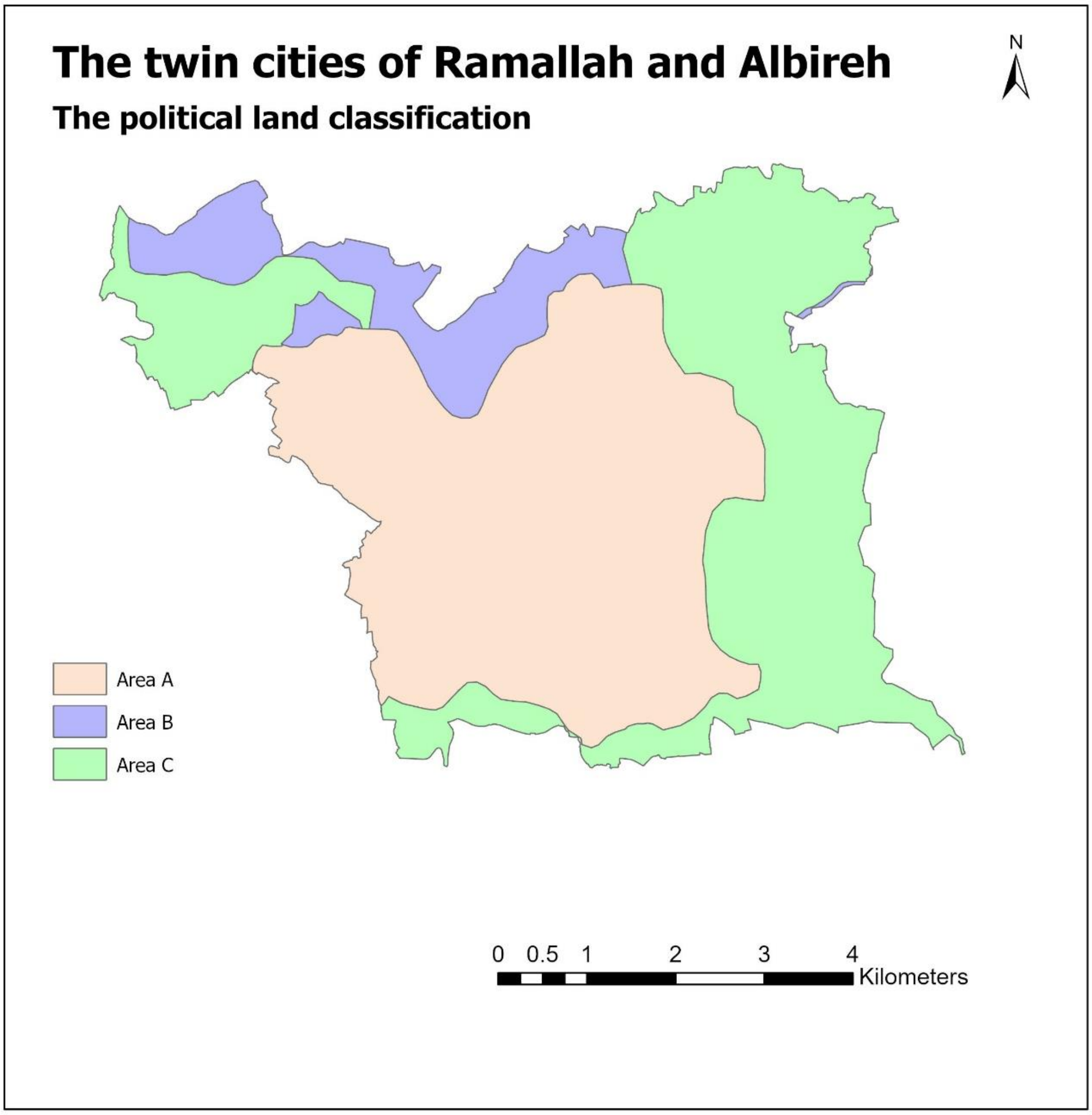

Figure 4-5: Political classification of the twin cities of Ramallah and Albireh (obtained from the ministry of the local government)

4.3.2 The twin cities' population and environment

The population of the twin cities is diverse in terms of origin and religious, political and cultural affiliation (Hilal and El-sakka, 2015). According to the 2017 census by the Palestinian Central Bureau of Statistics (PCBS), the population of the twin cities of Ramallah and Albireh numbered 86527 inhabitants (37138 in Ramallah, 43775 in Albireh, 4696 in Al Amari camp and 918 in Qadoora camp). The registered refugees living in the whole of the twin cities constituted almost half of their population (PCBS, 2019a). Individuals remain registered as a refugee after they leave a designated camp. The adult population of the twin cities had a relatively good level of education, and most of their economic activities were concentrated in the administration, trade and services sectors (government and private), and to a lesser extent, in the industrial sector (ARIJ, 2012a; Muhsen, 2017). The unemployment rate in the twin cities was around 16.2%, and poverty was reported to be slightly higher in Albireh than in Ramallah (MoLG, 2016; PCBS, 2017).

After the Oslo peace accords in the 1990s, economic growth was associated with an increasing gap between the social classes in the twin cities. Social heterogeneity has become more apparent than before (Taraki, 2008). The rise in the cost of living, the leap in land prices and the deepening of residential segregation created a place-based class distinction in the twin cities. For example, in 2016, land and housing prices in the twin cities rose about ten times the annual household income in the oPt (MoLG, 2016).

The distinction was apparent in the physical appearance of the twin cities of Ramallah and Albireh neighbourhoods and had far-reaching social consequences. After 1995, wealthy "upper-class" neighbourhoods emerged, with marked planning, substantial houses and villas, and high-quality services and amenities. In contrast, disadvantaged and informal areas, specifically refugee camps and areas politically classified as 'Area C', continued to lack adequate housing, infrastructure, and amenities. The middle ground between those contrasts lies in the lower-middle-class neighbourhoods. These are the most numerous and are characterised by crowded multiple-storey buildings with few green and open public spaces (Taraki, 2008; MoLG, 2016; Al-Shawamreh and Farhan, 2018).

In general, modernisation and development associated with urbanisation provided better resources and services to the population of the twin cities. However, it was also associated with challenges. This trade-off was seen worldwide, but in the twin cities and other cities in the oPt, the situation was dire due to historical and current geopolitical conditions and the lack of political control, allowing any foresight (MoLG, 2016; UN-Habitat, 2020).

The pivotal status that the twin cities started to hold in the late 1990s brought multiple challenges. The decision to use the twin cities of Ramallah and Albireh as the institutional, economic, and governmental centre was not backed by either an adequate infrastructural foundation or a sharp political vision to absorb the environmental consequences of the urban growth.

Historically, throughout the past urbanisation periods of the twin cities, the British, Jordanian, and Israeli planning schemes of Palestinian cities mainly served as an authoritative model more than a planning framework per se. These schemes ignored the population and development needs, and the urban expansion was predominantly random and far from being sustainable growth. Most notably during the Israeli period between 1967 and 1995. Israeli civil administration mainly focused on Israeli security and ensured the blocking of essential services and proper urban expansion of Palestinian cities (Moghayer, Daget and Wang, 2017).

After the advent of the Palestinian Authority and the construction boom that followed, the urban planning scheme was ineffective. It depended largely on the previous outdated and dysfunctional planning schemes. Random and uncontrolled urbanisation continued in many parts of the twin cities, and the planning policies fell short in addressing challenges related to urban sprawl. Despite reform endeavours in the recent decade, these stayed *shallow, weak and disintegrated* without evaluation mechanisms (Musleh, 2006; Helu, 2012; Hilal and El-sakka, 2015; Moghayer, Daget and Wang, 2017).

Furthermore, and more importantly, the twin cities' development and urban expansion were restricted and concentrated within the borders of areas controlled by Palestinians (‘Area A’ and ‘Area B’ classifications). Apart from the limited urban growth in areas controlled by Israel ('Area C'), where Palestinians have no authority for planning and development, the twin cities were surrounded by the separation wall, Israeli settlements, and Israeli bypass roads. These were crucial in disrupting and blocking the continuity of the urban landscape and future expansions and development (IDRC, 2004). For example, two Israeli settlements were constructed on 'confiscated' land of the northeast and the southeast of Albireh, which constituted 5.5% of its area (more than one square kilometre). There are other Israeli settlements in strategic locations surrounding the exterior of the twin cities (AbuSada and Thawaba, 2011; Lambert, 2015).

These geopolitical and demographic factors and the unguided densification of the urban environment in the twin cities of Ramallah and Albireh created enormous strains on lands, housing, and the natural environment. They produced highly compact patterns of urban growth in the areas politically classified as ‘Area A’ and "Area B" (UN-Habitat, 2014; UNEP, 2020). Urban densification came mainly at the expense of the natural green and agricultural lands. The twin cities suffer from a striking shortage of public and green spaces (Thawaba, 2014; Muhsen, 2017; Al-Shawamreh and Farhan, 2018; Nazer, Abughannam and Khasib, 2019). These challenges are undermining the sustainability of the urban environment, potentially posing significant adverse public health and environmental consequences, and are projected to worsen if a geopolitical change is not realised.

Moreover, the Israeli military controls all the roads leading to the twin cities. Barriers and checkpoints are scattered around the twin cities, obstructing the road networks connecting them with other parts of the West Bank and East Jerusalem. These are huge sources of congestion and pollution in the twin cities, disrupting people's lives, the environment, and the movement of goods (ARIJ, 2012a; Hilal and El-Sakka, 2015).

4.3.3 Health status in the twin cities of Ramallah and Albireh

The health infrastructure in the twin cities of Ramallah and Albireh has significantly improved with the advent of the Palestinian Authority. Several hospitals and clinics were established, and many health professionals migrated to work in the twin cities (Hilal and El-sakka, 2015). However, as demonstrated in the previous section, various political, social, and environmental determinants of health in the twin cities of Ramallah and Albireh negatively impacted their population's health.

Unfortunately, there was no available information about health exclusive to the twin cities of Ramallah and Albireh. No previous studies expressly referred to the twin cities alone, and this evidence gap was one motivating factor for my research. Some studies included the twin cities within their scope and provided little evidence. For example, a study about childhood cancer in the West Bank assessed and compared different locations. It found that an area that included the twin cities of Ramallah and Albireh had the highest relative risk compared to other sites in the West Bank (RR=3.05, p=0.00001) (Bailony *et al.*, 2011). However, this study included other localities close to the twin cities, so the results may not apply to the twin cities specifically.

4.4 Conclusion

This chapter provided an overview of the oPt and the twin cities of Ramallah and Albireh. It discussed the complex historical and geopolitical environment in the oPt, specifically the twin cities of Ramallah and Albireh. Understanding this is crucial to understanding the Palestinian context and current conditions and challenges. It demonstrated how the urban population increased dramatically in the last two decades while the urban space remained the same and how these aspects impacted the environment and the people. This chapter also introduced vital information about the urban features of interest in this research, namely the politically created disadvantage (refugee camps and areas politically classified as

'Area C') and urban green space, which I will investigate with the population's health.

The following chapter will present the data obtained for the analysis of this thesis and the final variables and dataset that will be used.

Chapter five: Data

To achieve the objectives of this thesis, I obtained secondary data from several sources. This chapter describes this data, how I handled it, and the variables I selected to use. The chapter has three sections. The first section will introduce the individual and household-level data from the 2017 census. I will describe the enumeration areas, the participants, and the process of selecting the health outcome variable and the individual/household level control variables. In the second section, I will discuss the different sources of area-level data, the information they contained and how I handled and prepared the area-level data. The last section of this chapter will discuss the variables I prepared for the analysis and the processes of constructing them. I used two software programs to explore, handle and prepare the data: R (versions 3.5.2 to 4.1.2) and ArcGIS from the Environmental Research Institute (ESRI) for geospatial processing (ArcMap 10.3 and ArcGIS pro). The R functions and packages that I used in preparing the variables and for the analysis are presented in Appendix C.

5.1 The 2017 census data of the twin cities of Ramallah and Albireh

In the process of searching for secondary data about the population of the twin cities of Ramallah and Albireh at the start of my research project, I identified that the 2017 census data was the best available option. Other data were available, such as the multiple Indicator Cluster Survey 2014 (PCBS, 2014); however, the information that identifies the geographical locations of the participants within the area of the twin cities was not available. Thus, the 2017 census was my primary source because it was representative and held geographical identifiers that could be linked to area-level features.

The census in the oPt conducted by the Palestinian Central Bureau of Statistics (PCBS) takes place every ten years, with the first census in 1997[9] and the most recent in 2017. The 2017 census covered the whole population of the West Bank and the Gaza Strip but only part of Jerusalem's population (because of Israel's restrictions). The 2017 census was conducted in two main phases: the enumeration and the data collection. The enumeration phase was around April 2017. In this phase, the PCBS teams used GIS technology to prepare maps of small areas (enumeration areas) and identified and collected data on all the houses and buildings within these areas. The data collection phase was conducted in December 2017. In this phase, the data collectors used electronic devices (tablets) linked to the GIS data to interview every household head (the main financial supporter) in the enumeration areas. The electronic data collection and handling tools, coupled with the GIS technology, played a significant role in obtaining high response rates and high-quality data (Awad and Abu Harb, 2020; Awad, Meng and Vittert, 2021).

I requested the dataset and the enumeration areas shapefiles (geospatial data format) of the twin cities of Ramallah and Albireh from the PCBS in October 2018. The PCBS accepted my request and sent the data in March 2019. This section will discuss the 2017 census data for the twin cities, the questions it contained, and the variables that I selected for analysis. I will start by describing the enumeration areas of the 2017 census, which I used in this research to represent residential areas or neighbourhoods.

5.1.1 The 2017 census enumeration areas of the twin cities

The PCBS used four levels of geographical boundaries for the 2017 census: regional, governate, locality and enumeration areas. The governate of Ramallah and Albireh in the West Bank has 84 localities[10] delineated by the "locality census

[9] I considered using the data from the 1997 or 2007 censuses in this thesis, but the PCBS refused to share the data.

[10] According to the PCBS a locality is “a permanently inhabited place, which has an independent municipal administration or a permanently inhabited, separated place not included within the formal boundaries of another locality and not have an independent administrative authority”.

boundaries". The smallest census boundaries within localities were the enumeration areas, dividing localities into groups of residential areas of approximately 150 housing units (PCBS, 2018).

I obtained administrative boundary shapefiles of the twin cities of Ramallah and Albireh from the PCBS. The spatial dataset included the boundaries of the Ramallah and Albireh localities, the two refugee camps within them, and the boundaries of the 228 enumeration areas. Figure 5-1 shows these boundaries, which also consists of a label for the location of the city centre of the twin cities of Ramallah and Albireh (called “Al-Manara square”).

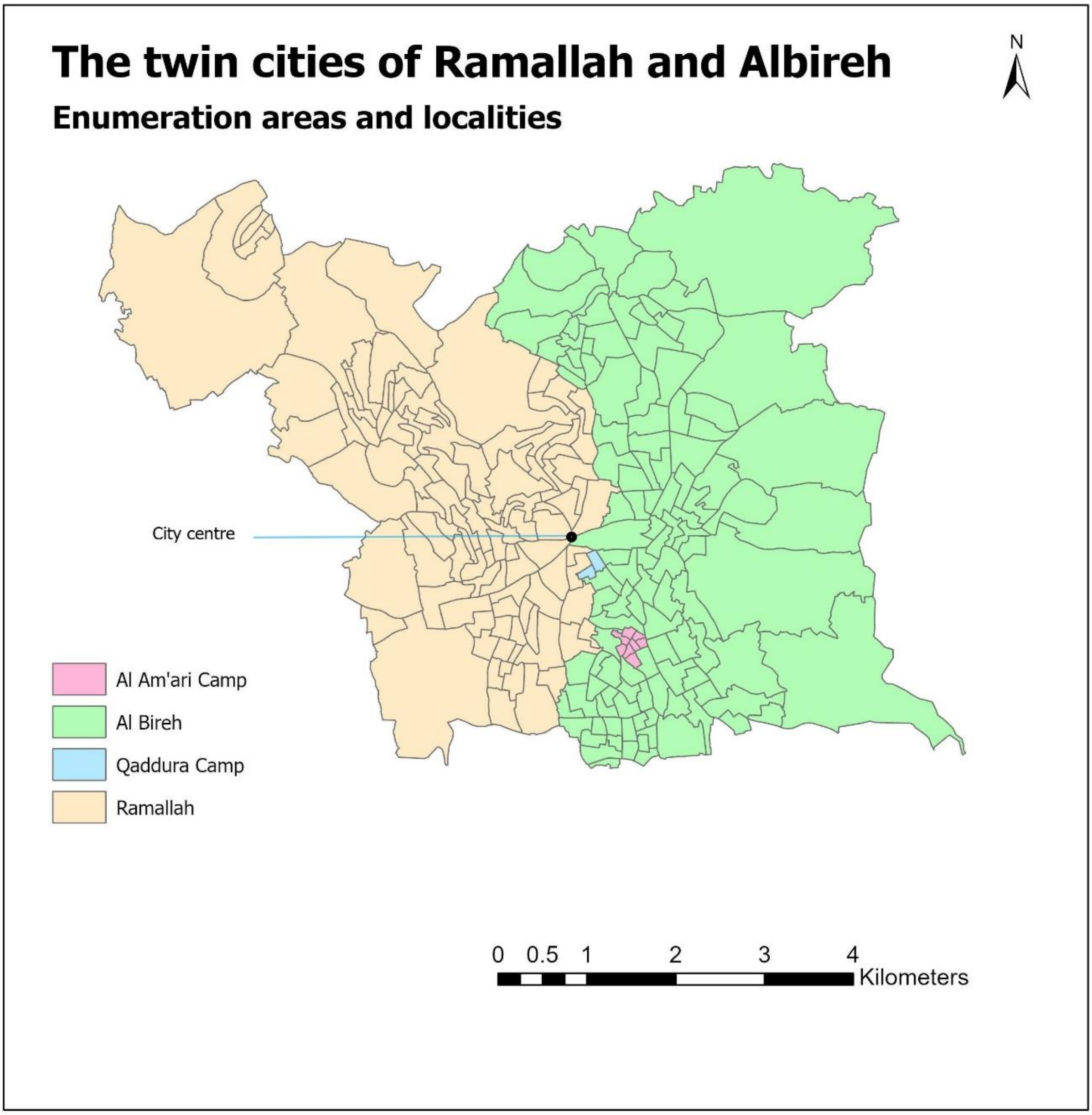

Figure 5-1: The twin cities of Ramallah and Albireh enumeration areas

5.1.2 The population and non-response of the 2017 census

The 2017 census targeted the entire population of the twin cities of Ramallah and Albireh, which included 86527 individuals (20241 households). There were, on average, 359 people per enumeration area. Figure 5-2 shows the number of people per enumeration area in the twin cities; darker colours represent the most populated areas, and lighter ones are the least populated.

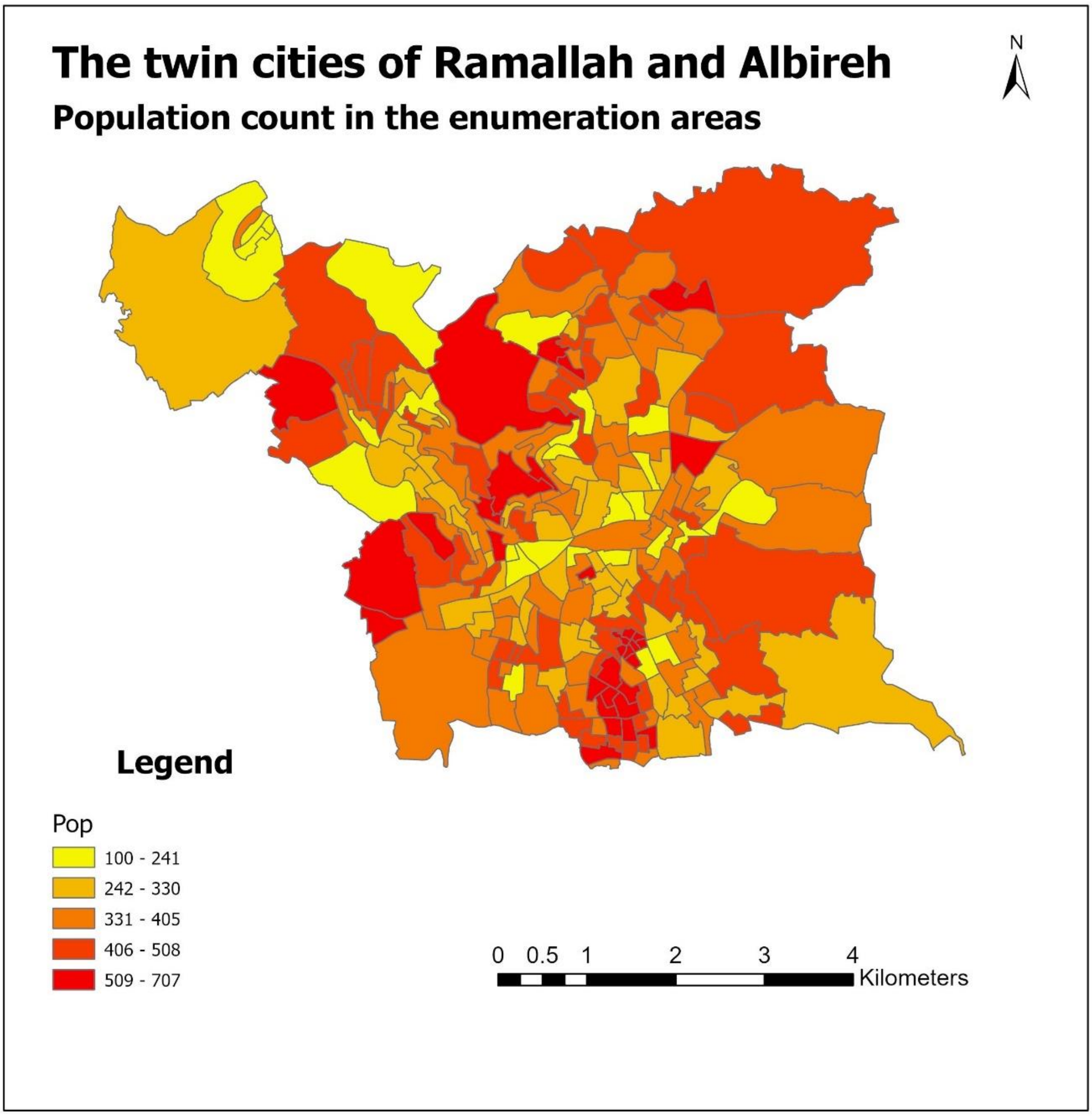

Figure 5-2: The total population count in the enumeration areas from the 2017 census

In the initial data cleaning phase, 4627 individuals (5.3%) were identified as containing missing data from all census questions apart from sex and nationality. According to direct communication with the PCBS, these missing values were due to non-response. The adult household members either refused to cooperate with data collectors (for unknown reasons) or were not found at home for an interview after several visits. According to the PCBS, the non-respondents have no common characteristics, although it was unclear how the PCBS came to this conclusion. Non-response rates were relatively low in all locations and, overall, in the study area, at just 5% (Table 5-1).

Table 5-1: The 2017 census population count and non-response in the four parts of the twin cities

Locality/refugee camp	Population count	Respondents	Non-response n	Non-response %
Ramallah	37138	34786	2352	6.3%
Albireh	43775	41574	2201	5.0%
Al Amari refugee camp	4696	4690	6	0.1%
Qadoora refugee camp	918	850	68	7.4%
Total	86527	81900	4627	5.3%

At the enumeration area level, 168 out of the 228 areas had some non-respondents, varying from 1% to 45% of their population (Figure 5-3). The areas with high rates of non-response (the darker colours) are distributed between Ramallah and Albireh localities. I explored whether there was a spatial influence over the non-response via Moran's I test of spatial correlation. It revealed a significant but weak spatial correlation; thus, they were not missing completely at random, contrary to the claims by the PCBS. Moran's I was equal to 0.18 (z-score = 10.3) at 1 km^2.

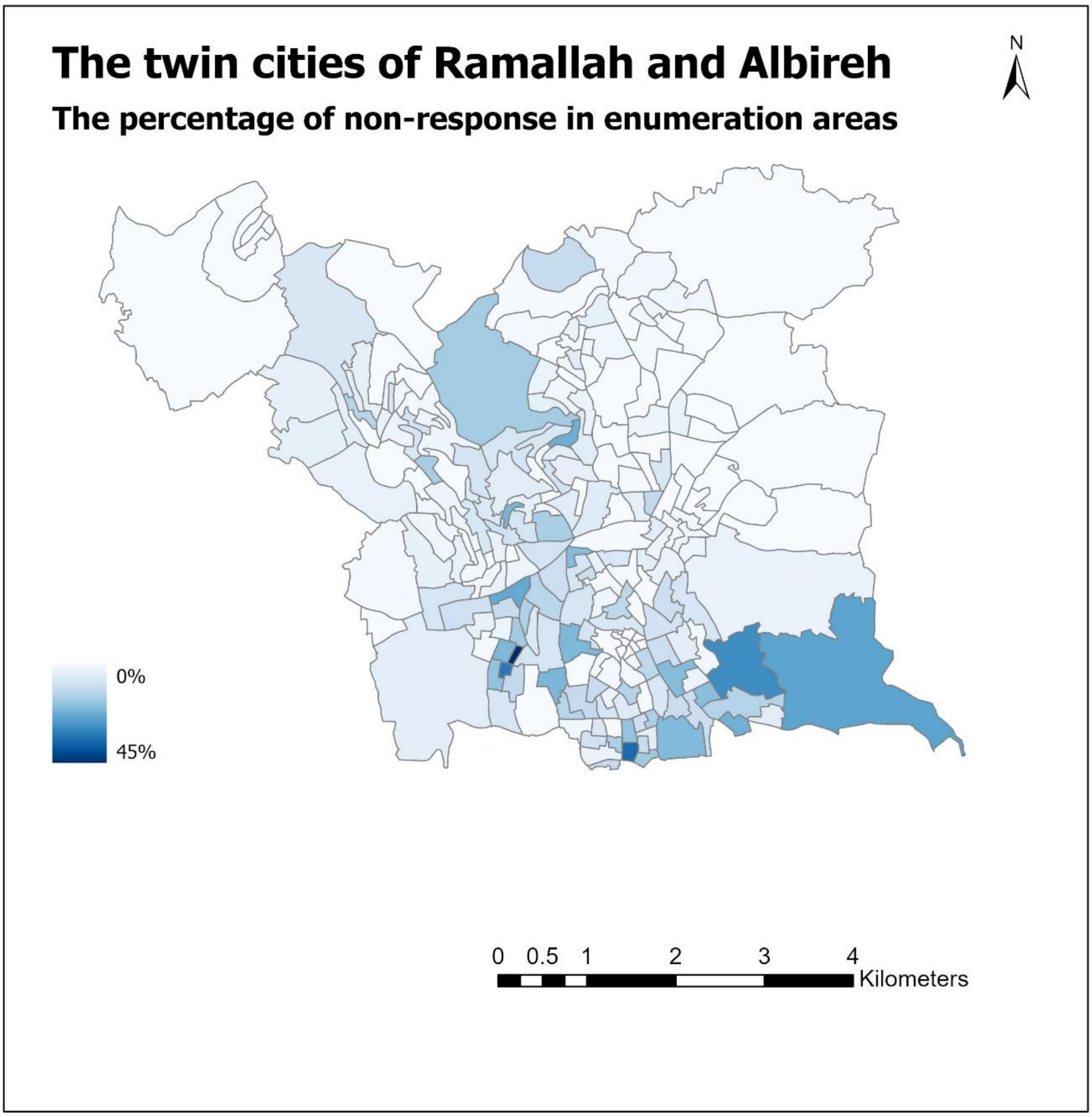

Figure 5-3: Percentage of non-response in the enumeration areas

Areas with relatively higher non-responses were examined online via Google Maps, Google Street View and by myself via on-the-ground assessment during my visit to the twin cities in the summer of 2019. I did not identify any specific common characteristics (e.g., social or environmental conditions).

Despite the non-response rates in enumeration areas showing as not completely random, which might be considered a weakness of the 2017 census data, the non-response was generally very low, and there were no viable means of imputation. Therefore, the non-respondents were removed from the data set. The total number of individuals in the 2017 census data set became 81900 (from 86527).

However, several census variables used in this study were restricted to individuals aged 14 and above. Thus, I excluded individuals below this age from the analysis (n=25087). Individuals who had zero years of residence (n=997) were also excluded as either not actually residing in the twin city (living in Israel or abroad) or being new arrivals without sufficient exposure to the local environments. This brought the sample size to 55816 individuals.

The missing values were low at 2% of the total sample (1123 cases). The level of missing values was less than 5% of the sample and was concentrated in three variables (refugee status, health insurance and chronic illness). I analysed the distribution of the missing values which were not patterned with other variables, presented in Appendix E. Thus, a complete case analysis was appropriate, and imputation was not required (Tabachnick, Fidell and Ullman, 2019). The final complete case analytical sample was 54693 individuals living in 18522 households in 228 enumeration areas (89% of all people aged 14 years or older).

5.1.3 Selection of variables from the 2017 census

The 2017 census questionnaire included 65 questions grouped into six sections or topics. These topics were:

- Housing conditions (e.g., type and tenure of the housing unit, source of drinking water and electricity and household assets and car ownership).

- Personal and health questions (e.g., sex, age, nationality, refugee status, disability, health insurance and chronic illness).

- Education (e.g., educational enrolment and attainment).

- Labour force participation and activity (e.g., relationship with the labour force, sector, and information about employer).

- Relationships and fertility (e.g., marital status, duration of marriage and number of live births).

- Mortality of a household member in the last 12 months, including information about the deceased.

In the next section, I will discuss the options for the health outcome variable from the 2017 census that I could have selected to use in the analysis of this thesis. I will state what I selected and why. Then, I will describe the individual and household-level control variables I chose to include in the analysis and the rationale for their selection.

5.1.3.1 Potential outcome variables from the 2017 census

The 2017 census included eight health or health-related questions, which could have been selected as outcome variables in this thesis. These were:

- Five questions about types of disabilities or difficulties and what caused them.

- One question about chronic illness.

- One question about the mortality of a household member in the last 12 months (including personal information about the deceased).

- One question about infant mortality in the household during the previous 12 months.

Below, I will describe these options and will state the outcome I selected and the justification for this choice as the most suitable option.

5.1.3.1.1 The five disability questions

The disabilities/difficulties questions in the 2017 census were about five types of difficulties: visual, hearing, mobility, comprehension, and communication. The answer options for each individual difficulty were: no difficulty; some difficulty; serious difficulty; or total inability. Each of these questions was followed by another about the reason for the disability, which consisted of 12 answer options:

congenital/genetic; problems related to pregnancy/birth; disease; physical or psychological violence; old age; work injury; road accident; other accident; Israeli military; war; psychological stress; other.

The disability variables were not selected as outcome variables in this research because they are mostly related to factors that rested beyond the context of residential areas (the interest of this thesis). Many of these disabilities are caused by genetic and pregnancy/birth problems or by external factors not related to the context of residential areas, such as work and occupational injury, traffic accidents and war/military violence. Therefore, there is a weak theoretical connection between these disabilities and the residential context.

5.1.3.1.2 <u>The general and infant mortality questions</u>

The two remaining options for an outcome variable from the 2017 census data were general and infant mortality in the previous 12 months. The general mortality question was: "did any household members pass away in the recent 12 months?" (Excluding those below 12 months of age). The infant mortality count was derived from two questions in the fertility section of the census. The first question was "the number of live births during the last 12 months", and the second was "the number of births still alive during the last 12 months". I calculated the incidence of infant mortality in the household by subtracting the numbers from the first question from the second question.

The incidence of infant and general mortality from the 2017 census was low and spatially sparse. In the twin cities of Ramallah and Albireh, the number of infant mortalities in 12 months was 21, a rate of 12 per 1000 births. These were in 19 out of the 228 enumeration areas in the twin cities. The incidence of general mortality in the twin cities in 12 months was also low at 212 (average of just under one death per enumeration area), making a crude death rate of 2.7 per 1000 individuals in the total population of the twin cities. Almost half of the enumeration areas of the twin cities did not have any deaths of a household member during the previous 12 months (Figure 5-4).

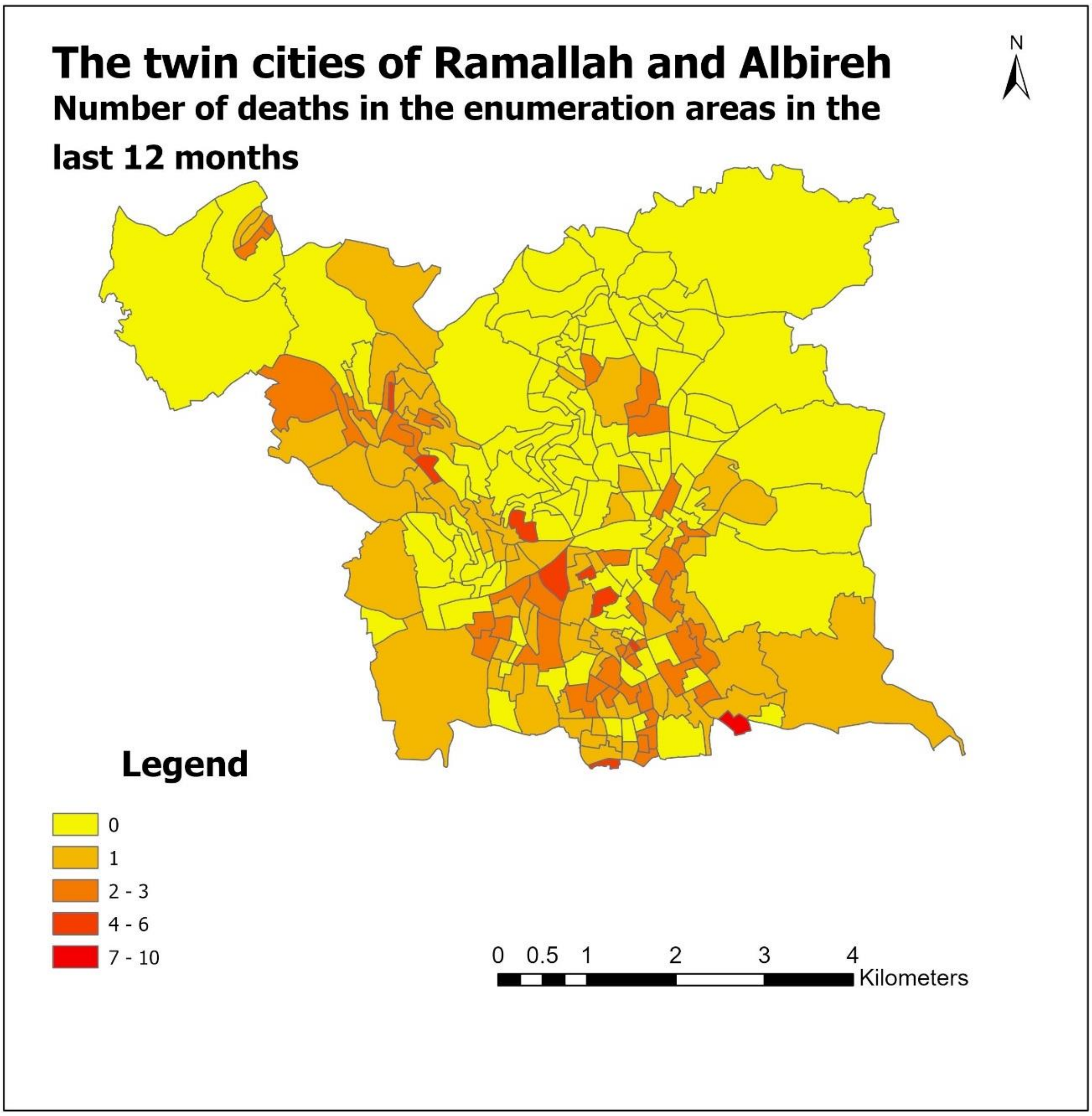

Figure 5-4: Number of deaths in the twin city enumeration areas

The sparsity of mortality recorded in the 2017 census presented a challenge. I investigated it further to ensure this was not a problem with the data. I identified that it was primarily attributed to the short time span for these variables (12 months). In my visit to the oPt in the summer of 2019, I succeeded in obtaining the mortality data covering five years for the twin cities from the ministry of health and the local health authorities to conduct a quality check of the 2017 census data. This data covered the period from 2013 to 2017. From this data, I discovered that the mortality information obtained from the census was valid, and the two sources of information matched. However, the mortality data I received from the local authorities were only geographically at the locality level. Therefore, this data could not be used to calculate the number of deaths in each enumeration area in the twin cities. In conclusion, because the mortality information from the 2017 census contained low numbers in the enumeration area, covered a single-year period, and no complimentary information was available, I abandoned the option of using mortality as an outcome.

5.1.3.1.3 The chronic illness question

The chronic illness question in the 2017 census asked: "do you suffer from any medically diagnosed chronic illness and receive continuous treatment" and the answer options were *yes* or *no*. The number of individuals in the twin cities who reported a chronic illness was 5295, representing 7% of the whole population of the twin cities. The prevalence of chronic illness was sufficiently distributed across the enumeration areas, with only three enumeration areas having no cases. I visualised the distribution of chronic illness in the twin cities by calculating the indirect sex and age-standardised chronic illness ratios at the enumeration area level (Figure 5-5). Enumeration areas with white colours represented areas with no chronic illness cases.

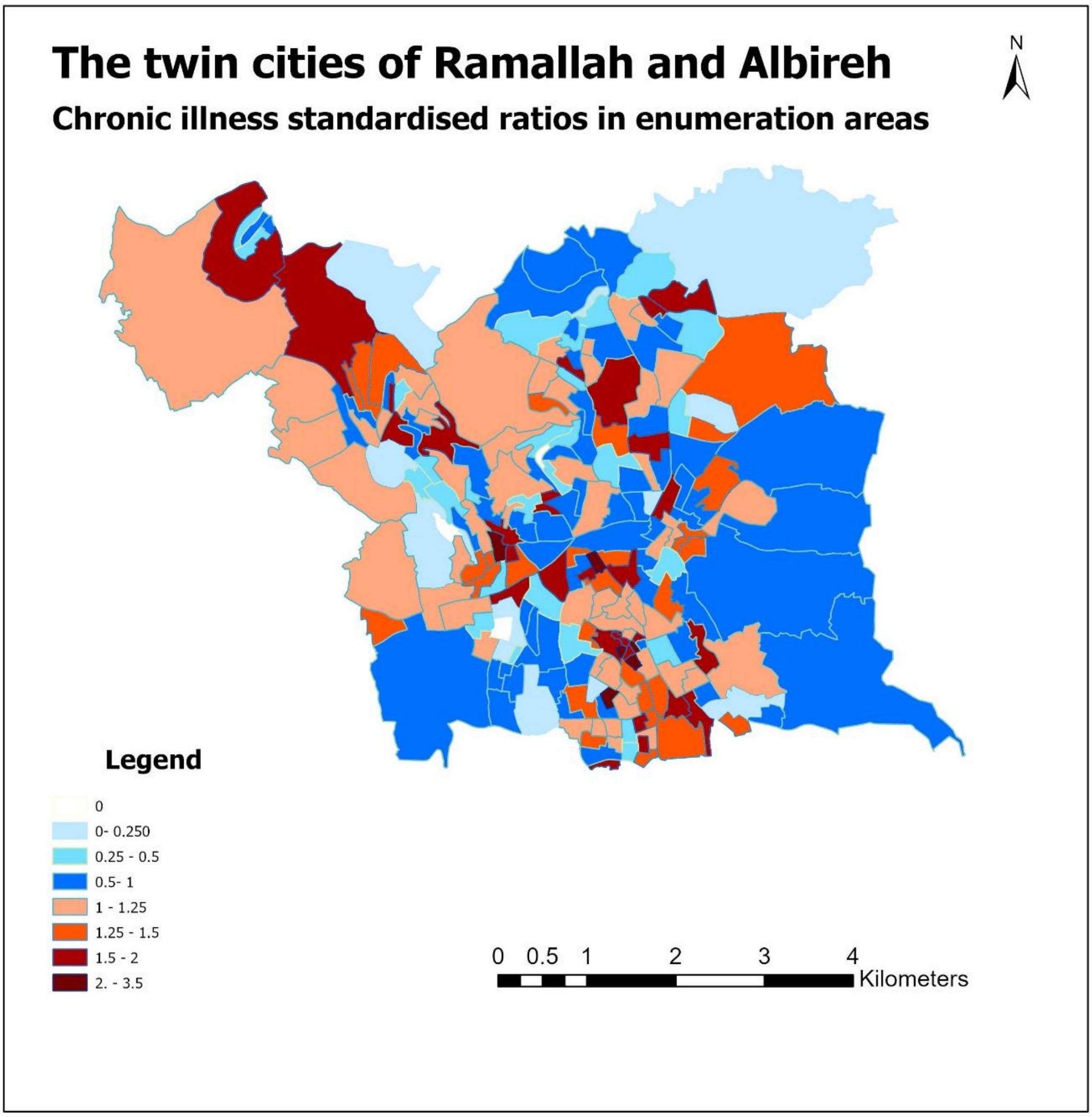

Figure 5-5: Indirectly standardised chronic illness ratios in the twin cities of Ramallah and Albireh

The indirectly standardised ratios were calculated by dividing the observed over the expected cases of chronic illness in each enumeration area. The expected cases were calculated by multiplying the age and sex-specific rates of the twin cities' population with the number of people in each enumeration area (Naing 2000). I used six age groups from zero to 75+ years old in 14 years intervals. The interpretation of the ratios in Figure 5-5 is as follows: areas in light and dark red represent the area with higher rates of chronic illness than we expect if they have the same age and sex-specific rates as the overall population of the twin cities. For example, an area with a ratio equal to 1.5 indicated that this area has 50% higher rates of chronic illness than we would expect, given rates across the whole population of the twin cities. The light and dark green areas represent the areas with equal or lower chronic illness rates than the entire population. These rates account for the age and sex structure of the people in the enumeration areas. Figure 5-5 showed no visually apparent clustering of enumeration areas. Still, some areas in the northwest, middle and middle south areas seemed to have higher chronic illness rates than other areas in the twin cities.

5.1.3.2 Selection of individual and household-level questions

I selected several individual and household-level questions from the 2017 census to be used as control variables in the analyses (Table 5-2). The rationale for choosing these individual and household-level questions was based on three criteria. The first criterion was theoretical significance to the objectives of this thesis – relating the environment to health. Accordingly, I included personal and household characteristics that are known to influence health. These included: age, sex, marital status, and personal and household socio-economic variables. Other variables were included to reflect the specific context of this study, including health insurance and refugee status (described in the previous chapter). Years of residence in the enumeration area variable was selected because it was an important confounder of the relationship between attributes of the residential area and health outcomes.

The second criterion was that items should have sufficient variability across the population. For example, variables such as nationality, sources of household drinking water, energy and electricity were not selected because they had variability close to 1%, meaning the answers to the questions had high similarity across the study population. The third criterion was that questions should not have been specific to certain small population groups. For example, the census contained some questions specific to the population of workers. Not having responses for large sections of the population would cause difficulties in the modelling and interpretation.

Table 5-2: PCBS 2017 census questions

#	Item/ variable	Categories
Household and housing conditions		
1	Type of housing unit	Villa, house, apartment, independent room, tent, marginal/caravan/barracks, other
2	Tenure of the housing unit	Owned, rented unfurnished, rented furnished, without payment, for work, other
3	Count of durable goods and facilities in the house 1. Kitchens 2. Bathrooms 3. Toilets 4. Bathroom and Toilet together 5. Private Car 6. Gas /Electric stove 7. Refrigerator 8. Freezer 9. Vacuum Cleaner 10. Microwave 11. Washing Machine 12. Drying Machine 13. Dish Washer 14. Water Filter 15. TV/ LCD/ LED screen 16. Television 17. Satellite 18. Electric Fan 19. Air Condition 20. Central Air Condition 21. Central Heating 22. Solar Boiler 23. Phone line 24. Home Library	 No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No. No.
4	Technology usage 1. Palestinian Internet 2. Israeli Internet 3. Palestinian Mobile 4. Israeli Mobile 5. Computers 6. Laptops 7. Tablets \ iPads 8. Smart Phones 9. Number of household members using computer	 No. No. No. No. No. No. No. No. No.
Individuals Information		

#	Item/ variable	Categories
5	Sex	Male, female
6	Age	In completed years
7	Marital status	Never married, legally married, married, divorced, widowed, separated
8	Duration of residence in the area	In completed years
9	Refugee status	Registered refugee, non-registered, refugee, non-refugee
10	Health insurance	None, governmental only, UNRWA[11] only, private only, governmental and UNRWA, governmental and private, UNRWA and private, Israeli, others
11	Educational attainment	Illiterate, can read & write, elementary, preparatory, secondary, intermediate diploma, bachelor, higher diploma, master, Ph.D
12	Relation to labour force	Worked 1-14 hrs, worked 15 – 34 hrs, worked 35 – 45 hrs, worked 46 hrs and above, (doesn't work but want to work / worked before), did seek for work last 4 weeks, (does not work but want to work/never worked before), did seek for work last 4 weeks, (does not work and does not want to work because…), studying/ training, housekeeping, disability/ aging/ illness, having another source of income, retirement, other

[11] UNRWA is the United Nations Relief and Works Agency that provides health care for the Palestinian refugee population

5.2 Area-level data

In the initial stages of my research, I searched for data about the political and built environment in the twin cities of Ramallah and Albireh. I found that three sources might provide me with these data: the ministry of local government, the municipalities of Ramallah and Albireh, and the Applied Research Institute Jerusalem (ARIJ). The ministry of local government and the municipalities of Ramallah and Albireh have online GIS portals for information, such as different political boundaries, land parcels and their classifications, buildings, amenities, and the urban master plan of the twin cities. ARIJ is a research centre that previously published several reports about the environment of the oPt, including the twin cities. Through exploring these reports, I found that they published maps of land cover across the oPt.

After investigating each of these sources and identifying spatial data that might help me in my research, I contacted each organisation. They all expressed their willingness to share the data; thus, I applied for and obtained the GIS data I needed during September-November 2019. I received political boundaries from the ministry of the local government, in addition to an aerial photograph of the twin cities area. I obtained different attributes of the built environment in the twin cities of Ramallah and Albireh from the municipalities. And finally, I received GIS data about the land cover in the twin cities from ARIJ.

The following section will describe the data obtained from these different sources, how I used it, the problems they contained, and the methods I used to edit and improve the data.

5.2.1 GIS data from the ministry of local government

The Palestinian ministry of local government provided me with two sources of GIS information about the twin cities of Ramallah and Albireh that I used in this thesis. First, I obtained the data about the political land classification from the ministry of the local government's GIS portal (https://www.molg.pna.ps). A map layer delineates each political land classification (Area A, B, C) within the twin cities (presented in the previous chapter, Figure 4-5).

Second, I requested and obtained an aerial (orthogonal) photograph of the twin cities of Ramallah and Albireh from the ministry of the local government, dated June 2018. This aerial image was used as a superior alternative to Google maps because it was a higher-resolution image (1 meter per pixel). It provided a closer and clearer view of the twin cities, thus facilitating detailed editing of the GIS maps at a fine scale. I used this image in editing the green space data, which will be described later in this chapter.

5.2.2 GIS data from Ramallah and Albireh municipalities

The data obtained from Ramallah and Albireh municipalities included GIS data for 2019 about the urban master plans, buildings, streets, amenities, street lighting and the sewage system. The urban master plans included data about different types of land use in the twin cities, such as land use categories (e.g., residential areas, economic areas, public parks, and community gardens).

I initially thought to use the GIS data from the municipalities in the analysis of this thesis as contextual variables, either as control variables or, in the case of public parks and community gardens, as explanatory variables. However, after exploring the GIS data from the municipalities and comparing it with the aerial image, I found that they had three critical problems.

First, the data stemmed from two different sources (Ramallah municipality and Albireh municipality), and there were differences in coverage and definitions between them. For example, street lighting data existed for Albireh but not for Ramallah, whilst the opposite was found for data on the sewage system. Without full and consistent coverage across the study area, variables could not be used.

Second, most of the data obtained from the municipalities was incomplete. Areas of the twin cities classified politically in the jurisdiction of ‘Area A’ and ‘Area B’, i.e., under Palestinian administration, were relatively complete. In contrast to 'Area C', under the Israeli administration, only attributes of buildings and streets were complete.

Third, the data about streets were taken from the urban master plan; thus, the problem was that they did not reflect what existed on the ground; they were plans for the twin cities in the future and included streets that are yet to be developed.

In summary, from the GIS data obtained from the municipalities, only buildings and streets that were complete and of good quality thus could be used in the analysis. However, the street data did require editing to remove planned streets (not yet built). I used the buildings and streets data from the municipalities to update the land cover data from ARIJ, discussed in the following section.

5.2.3 Land cover data from ARIJ

I obtained the land cover of the twin cities of Ramallah and Albireh data from ARIJ in November 2019 (Figure 5-6). ARIJ created this data around 2011-2012, and it includes seven subcategories of land cover:

- Arable land: areas suitable for agriculture (not necessarily cultivated).
- Permanent crops: agricultural trees of the same type (mainly olive trees).
- Heterogeneous agricultural areas: a mix of different kinds of agricultural trees such as olive, fig, vine, almond, and other fruit/nut trees.
- Artificial non-agricultural vegetated areas: sports grass fields.
- Forests: refers mainly to concentrations of coniferous trees such as Pinus and Cupressus trees.
- Shrub and/or herbaceous vegetation: small or medium-sized bushes associated with other wild vegetation. Mainly refer to 'Pittosporum spinosum' and other wild woody herbs such as Thymus and Salvia species.

- Open spaces with no or little vegetation: land poorly suitable for agricultural uses.

Figure 5-6 below shows orange areas in the northeast and southeast of the twin cities. These correspond to the Israeli settlements and military bases in the twin cities of Ramallah and Albireh and other extension areas that consist of military posts and sanitation services or serve different functions to the Israeli settlements. Most of these Israeli areas are surrounded by a concrete wall or metal fence, and their access or use is restricted to the Palestinians. The land cover in these areas was not mapped in the data from ARIJ.

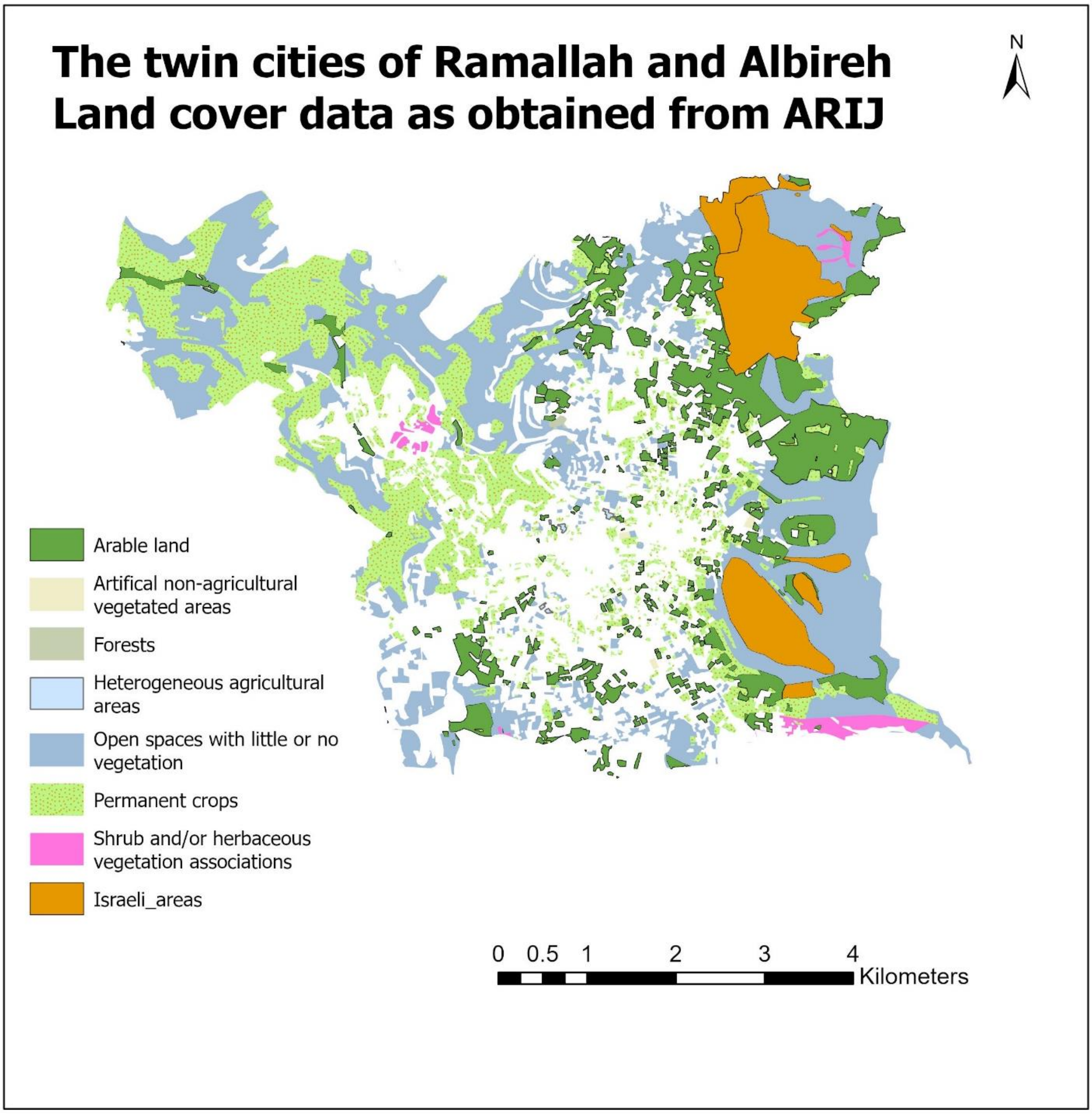

Figure 5-6: Land cover map obtained from ARIJ

The main strength of the land cover data from ARIJ was that it differentiated between various types of green space across the twin cities. That was useful to separate between types of green space in the analysis of this thesis, as recommended by the scholars working on the link between green space and health, discussed in chapter three.

I explored the data from ARIJ to examine its quality, comparing it with aerial photographs from ESRI and Google Maps and via closer inspections using Google Street View. It appeared to have two problems: First, it was published in 2011-2012, thus, reflecting the land cover at least five years before the 2017 census. When I compared it with aerial photographs and Google Street View, dated 2018 (close to the census date), there were several differences between the two maps. Second, the data had some problems; in some places, it was incomplete, and in others, there were incorrect land cover classifications. I determined that the missingness and errors were substantial; however, it would be possible to edit and update the land cover data obtained from ARIJ. This process is described below.

5.2.3.1 Editing methodology of the land cover data

I used ArcMap GIS software (v. 10.3) for the land cover editing processes. The data were projected in the coordinate system of the Palestine 1923 grid. Before updating the land cover data obtained from ARIJ, I used the data layers for buildings and streets (paved and not paved) from the municipalities to update data with the new built-up sections that took place in the period since ARIJ data was created (before 2012) until 2017 (the year of the census). I achieved this by overlaying the built area map and land cover layers and then erasing the buildings and roads from the original land cover map. This created a new land cover map with updated built-up areas. As discussed in the previous section, the GIS data about streets included sections that did not exist on the ground (part of the urban master plan). However, I solved this problem in the next step of updating the land cover layer by manually and systematically editing land cover categories.

I anchored the editing of the land cover map to the nearest time period of the census (2017), so where possible, edits were made to represent the urban context of that time. Therefore, the 2018 aerial image obtained from the ministry of the local government was the primary source of information in the editing process. The high-resolution aerial image facilitated editing at a fine scale, permitting the mapping of small patches of green space, such as street trees and around houses and buildings, and differentiating between green space categories. However, when there was uncertainty about the type of green space, Google Street view was used as the definitive source of information where it was available. Some places in the 'Area C' region of the twin cities did not have Google Street View information. There, I used only the information from the aerial photograph.

To ensure a systematic editing approach, I used a fishnet grid with a cell size of 100 meters square over the whole area of the twin cities. I used the grid to sequentially edit each cell, thus preventing any areas from getting missed. Within each cell, I thoroughly compared the land cover data layer obtained from ARIJ to the orthogonal satellite imagery, and whenever there were differences, updates were made. Most of the editing was on the following:

- Around the locations where I had updated the land cover data with the new streets and buildings in the previous editing step.

- At the places where the ARIJ data was incomplete. For example, ARIJ data did not include street trees and green spaces close to built-up areas. Mapping at a fine scale allowed including these spaces in the updated map.

- At the places where the ARIJ data was improperly labelled. For example, ARIJ data labelled some areas used as car parking or dumping sites as open spaces with little or no vegetation. These were not included in the updated map, and some areas were labelled as 'permanent trees', but after inspection, they appeared to be 'coniferous' or 'heterogeneous trees' and edited accordingly in the updated map.

- Around Israeli areas, because most of these were not included in the data from ARIJ, I used the walls and fences as markers of Israeli areas, excluded all the areas inside these barriers, but made sure to include all areas outside. The rationale was green spaces not surrounded by a barrier are still accessible, at least visually, to the nearby residents.

In defining each land cover category, I created a new polygon or reduced the size of the existing polygon to only the area containing that category (Rujoiu-Mare and Mihai, 2016). There was no minimum or maximum polygon size; it depended on the size of each land cover category in that area. In the case of trees or shrubs, there was no minimum number of trees or shrubs (i.e., threshold), and the area of every patch of green space was identified with a polygon regardless of its size. One exclusion was for single scattered trees or shrubs in remote large open spaces or arable lands (mainly in the peripheries of the twin cities); these were not identified.

The following section explains how I verified the different categories of land cover. I first grouped the land cover categories into those that included trees and those that did not have trees to facilitate differentiating between relatively similar land cover categories. The following section also shows some images from the aerial photograph and Google Street View to demonstrate how these categories appeared in these images.

5.2.3.1.1 Categories without, or with very few, trees

Four categories did not include trees. These were arable land, open space with little or no vegetation, shrub areas and artificial vegetated surfaces. The artificial non-agricultural vegetated surfaces refer to sports fields. Only three sports fields in the twin cities had a grass surface, as indicated by the original data from ARIJ. After editing, this category remained the same, but I changed its name to the sports field.

Arable land is land used for agriculture or suitable for agricultural use. It might be vegetated with small plants or not vegetated. The non-vegetated arable lands were identified by the uniform brown colour or any agricultural activity markers, such as ploughing markers (Figure 5-7). The vegetated arable lands were identified by the uniform striped, green colour or covered with plastic covers as markers of planted vegetables or other harvests.

Figure 5-7: Arable Land in the orthogonal and Google Street View images

I identified the 'open space with little or no vegetation' category by the light brown colour and the presence of white or grey spots indicating a rocky or chalky soil, thus not suitable nor used for agriculture (compared to arable land) (Figure 5-8). I did not include unpaved roads, open spaces for car parking, construction sites, and dumpster sites with solid waste or construction debris as open spaces with little or no vegetation.

Figure 5-8: Open space with little or no vegetation in the orthogonal and Google Street View images

I identified the 'shrub and/or herbaceous vegetation associations' category from scattered dark green colours, mainly in a circular shape (Figure 5-9). I easily identified large and medium size shrubs from their distinct form. However, in the case of small-size shrubs or herbs, it was difficult to differentiate between categories of 'shrub and/or herbaceous vegetation associations' and 'open space with little or no vegetation'. In many instances, ' open space with little or no vegetation' included small shrubs and herbs. Thus, the category of 'shrub and/or herbaceous vegetation associations' mainly comprises areas that contain large and medium-sized shrubs.

Figure 5-9: Shrub and/or herbaceous vegetation associations in the orthogonal and Google Street View images

5.2.3.1.2 Land cover categories with trees

Three land cover categories included trees: forests, permanent crops and heterogenous agricultural areas. The forests category referred to areas that mainly included coniferous trees. Because forests are commonly defined as large areas covered with trees or dense masses of trees that do not exist in the twin cities, I renamed this category coniferous trees. The coniferous trees label provides a better description of small patches of coniferous trees in the twin cities than forests.

The three categories of land cover with trees differ in the type of trees they contain. From its name, the coniferous trees category consists mainly of coniferous trees. The permanent crops category is the land that includes the same type of crop trees and is predominantly olive trees, but it may also contain or consist of almond, fig, and fruit trees. The heterogeneous agricultural areas category includes different types of trees and may be associated with other kinds of vegetation such as grasses, flower beds and ornamental trees.

While editing, the difference between these categories was based on the pattern, sizes, and colour of trees. The permanent crops are recognised mainly based on the uniform pattern of the planted trees, the presence of stone bunds in sloping land, and the soil's colour (typically brown, resembling arable land) (Figure 5-10). These are distinct from coniferous trees, which are less patterned, and the soil colour is greyer, caused by the presence of rocks and wild herbs (Figure 5-11). Permanent crops and coniferous trees are also different in terms of the sizes of trees. They are larger in the coniferous trees category compared to permanent crop trees.

On the other hand, the heterogeneous agricultural land includes different types of trees, captured by the mix of different tree sizes and colours (Figure 5-12). The heterogeneous agricultural areas are also mainly situated beside or around residential structures, such as houses and buildings. This category is nearly exclusively private vegetation, gardens, or street trees, unlike coniferous trees or permanent crops categories which are mainly open tree plantations and usually on the peripheries of residential areas or between sparsely arranged houses.

Figure 5-10: Permanent crop trees areas as appears in the orthogonal and Google Street View image

Figure 5-11: Coniferous trees as appears in the orthogonal and Google Street View images

Figure 5-12: Heterogeneous agricultural trees areas as appears in the orthogonal and Google Street View images

5.2.4 The updated land cover data

The detailed editing, quality checking and reclassification of the land cover data was a substantial task and took a significant amount of time (approximately two months). After editing, I assessed each grid square for the second time to ensure the accuracy of the spatial land cover data layer.

After the land cover data was ready, the area size of the land cover categories in the twin cities was reduced by 0.61 km^2 between the original and the edited data. Most of the grid cells were edited. However, that does not mean that this reduction was exclusively from the expansion of built-up areas to these lands between 2011 and 2018. As I mentioned earlier, there were a fair number of errors in the original data that were corrected by the editing process. Figure 5-13 shows the final land cover map in the twin cities of Ramallah and Albireh produced after editing the data from ARIJ. The seven categories of land cover had an area of 22.4 km^2, constituting 58% of the whole area of the twin cities. Among the seven land cover categories, open spaces with little or no vegetation were the most common land cover, followed by permanent crops and arable land.

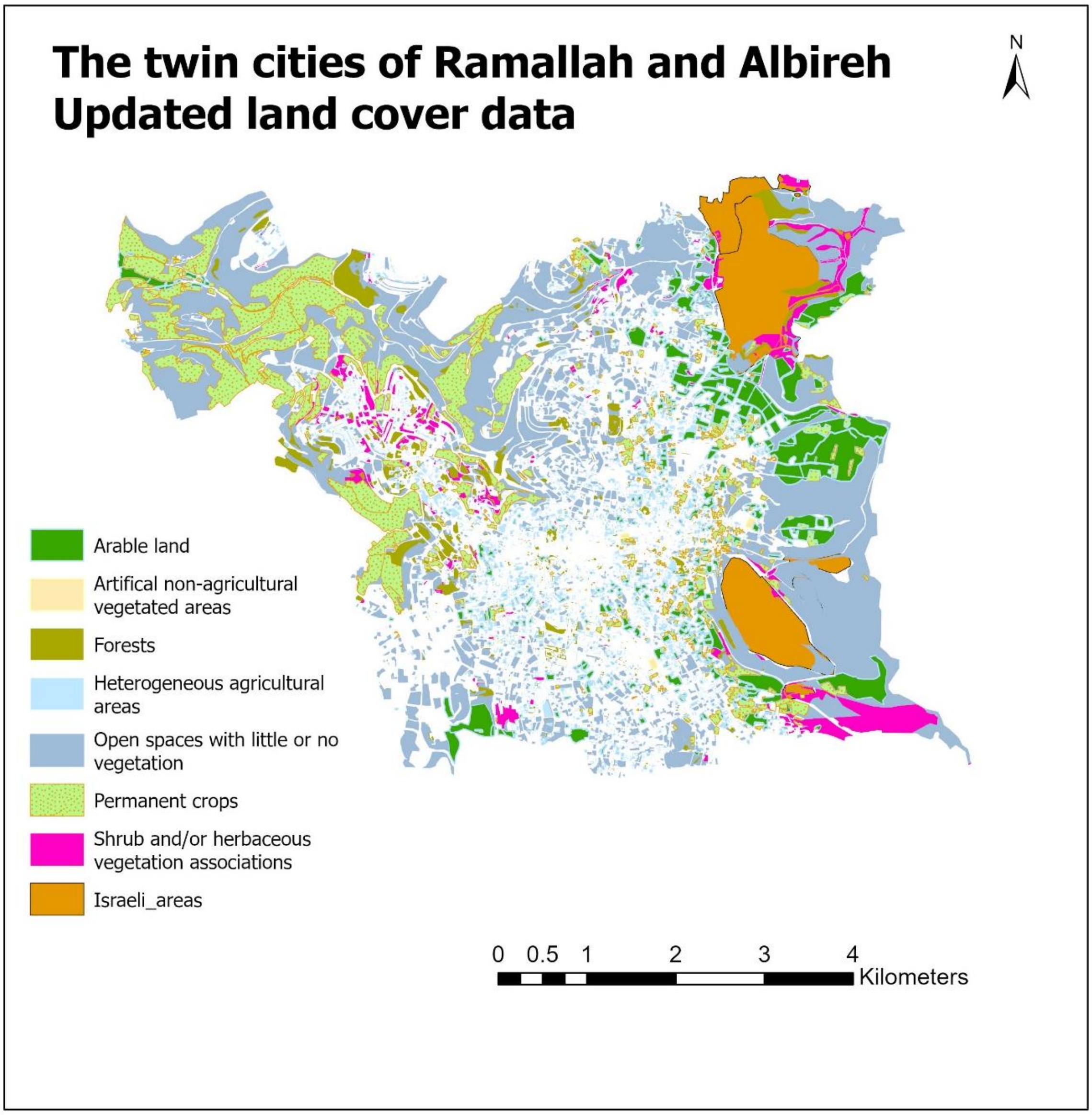

Figure 5-13: Land cover map from ARIJ after editing

Figure 5-14 below shows the percentages of the different categories of natural land cover in the twin cities and the built and Israeli areas. Built areas (not shown in Figure 5-13 above) such as buildings, roads, parking lots and other built structures constitute the largest proportion of the twin cities area, followed by the open space without or with little vegetation. The sports fields category, not shown in Figure 5-14, constituted 0.05% of the whole area of the twin cities.

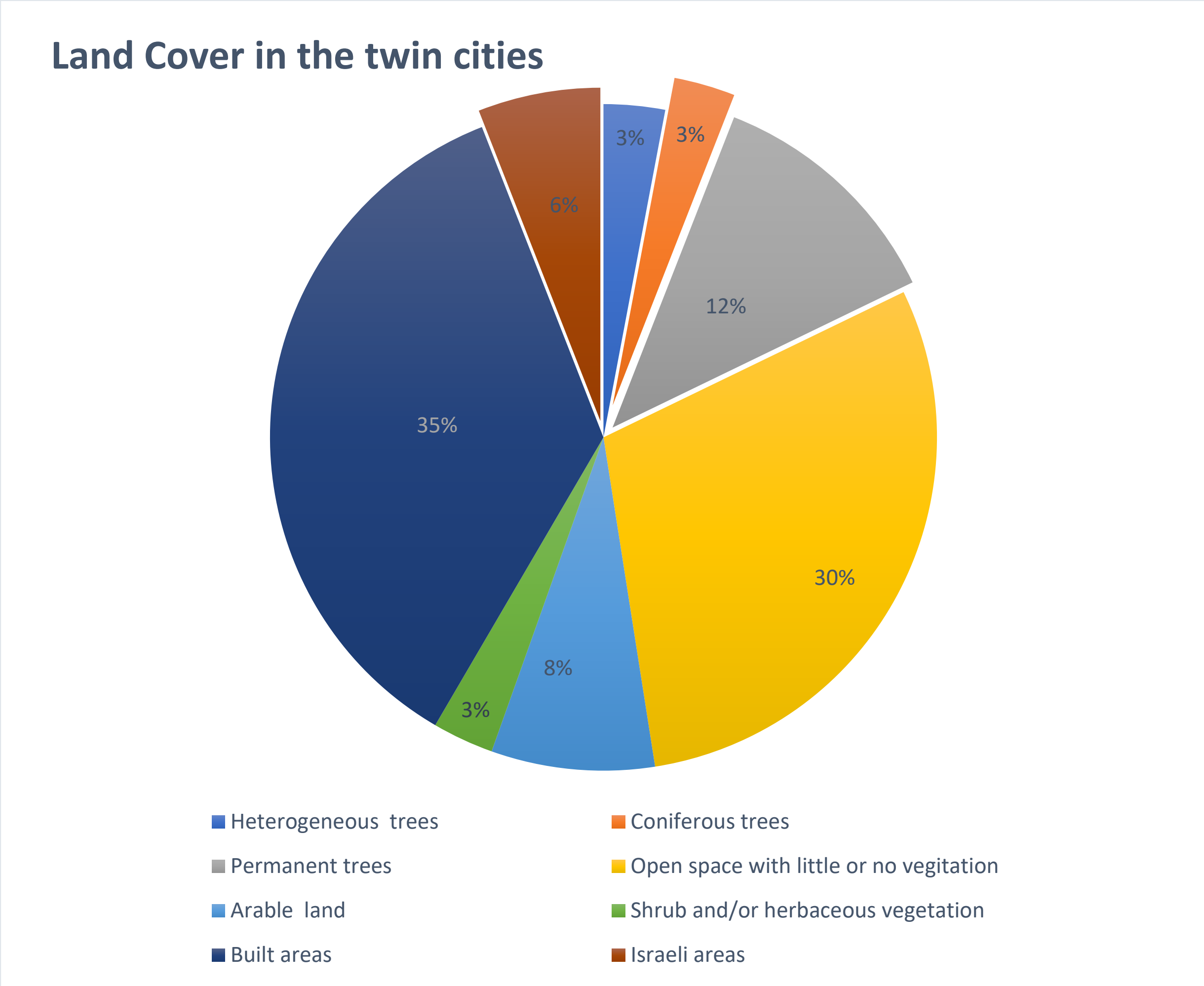

Figure 5-14: A chart of proportions of land cover in the twin city of Ramallah and Albireh

5.3 Preparing and re-coding variables for the analysis

So far, in this chapter, I have presented the individual and household-level data from the 2017 census and the political boundaries and land cover of the twin cities of Ramallah and Albireh. This section will discuss how I prepared the variables for the analysis. The first part of this section will address the preparation of the individual and household-level variables. The second part will address the area-level variables.

5.3.1 Individual and household-level variables

The variables selected from the 2017 census data included two continuous variables (age and years of residence in the area); these variables were not changed. All the remaining variables were discrete (categorical) variables. I re-coded all the categorical variables except sex (female, male) which did not require transformation. Merging categories was necessary for the analysis because most of these variables included categories with small numbers of individuals or housing units, and sometimes there were empty categories.

Table 5-3 presents all the categorical variables before and after the new coding. I merged the categories with a few numbers with other similar categories. I transformed the refugee status into a binary variable (refugee or not refugee) because the number of unregistered refugees was low, thus adding to the category of registered refugees forming a new category named refugees. I combined the different types of health insurance into a new category, referring to those with any form of health insurance. The participation in labour force variable included separate categories for '*employed*' and '*unemployed*' as those in the labour market and separate categories for '*housework*', '*students*', and '*other*' as those out of the labour market but with likely different lifestyles. I combined the educational attainment categories into five categories: university education, high school; preparatory level; primary level; and no formal education. Marital status re-coding was into three categories: married, never married, and other.

In the housing conditions variables, the type of housing units included an empty category (tent) and other categories with very few numbers (room, caravan and other), which I combined with the apartment. While I combined the villa and house categories into one category, thus, the new variable was binary: villa or house and apartment. The tenure variable also included empty categories (for free and exchange for work) and categories with few numbers; thus, I transformed it into a binary variable: own and rent.

Finally, and similarly, because of low numbers, I transformed all the household assets variables from count variables into binary variables indicating the presence or the absence of these assets in the household. I initially thought to convert them to three categories rather than two, but the numbers were very small for most of the variables for a third category (two or more assets owned by a household). I used all the household assets variables except car ownership to construct a household assets scale, discussed in the following section. The reason for not including car ownership in the household assets scale was because it was different in terms of importance and function to living conditions and its economic value than the other household assets. Car ownership was a binary variable: no car and one or more cars.

Table 5-3 presents all the categorical variables in the original and the combined categories, except the household's assets combined into a scale and discussed in the following section.

Table 5-3: Re-coding household and individual level census variables

Item	Original coding	Merged coding
Sex	Female	Female
	Male	Male
Refugee status	Registered refugee	Refugee
	Unregistered refugee	
	Not refugee	Not refugee
Health insurance	Governmental, UNRWA, private, combinations, Israeli, other	Yes
	No	No
Participation in labour force	Categories of work hours	Employed
	Unemployed	Unemployed
	Studying	Studying
	Housework	Housework
	Old or disabled	Other
	Income without work	
	Retired	
	Other	
Educational attainment	PhD	University
	Master	
	BA	
	Diplomas	
	11-12 years (high school)	High school
	7-10 years (preparatory)	preparatory
	1-6 years (primary)	Primary
	Literate (no education)	No education
	Illiterate	
Marital status	Married	Married
	Legally married	
	Never married	Never Married
	Engaged	
	Divorced	Other
	Separated	
	Widowed	
Type of housing unit	Apartment	Apartment
	Room	
	Tent	
	Caravan/shack	
	Other	
	House	House or Villa
	Villa	
Tenure	Own	Own
	Rent furnished	Rent
	Rent non-furnished	
	For free	
	Exchange of work	
	Other	
Private car ownership	Count	One or more cars
		No car

5.3.2 Household assets scale

Ownership of assets at the household level is a widely used indicator for households' socio-economic conditions reflecting long-term wealth. Household assets, in terms of ownership of consumer items and facilities, are considered a benchmark of a standard of living and quality of life (Rutstein and Johnson, 2004). There is no standard measure of household affluence in the oPt. Therefore, for this purpose and to reduce the number of variables in the analysis, I used the household assets questions from the 2017 census to create a household assets scale. This section will discuss the methodology I used to create this scale.

5.3.2.1 Selecting and combining variables for the scale

The 2017 census questionnaire included questions about 32 household assets. Based on their socio-economic relevance and variability, I included 13 out of the 32 on the assets scale. I excluded the remaining 19 assets for the following reasons: five did not present any variability, and their frequency was almost 100% in all households. These were the kitchen, fridge, cooker, washing machine, and bathroom & toilet. I excluded the remaining assets because they were not socio-economically relevant and did not differentiate between high- or low-income households as they can be substituted with other assets or technologies. These were the electric fan, solar boiler, and satellite.

From the remaining household assets, there were pairs with similar value and function and, when combined, did not represent variability. I excluded those which did not represent variability when combined (mobile phone from a Palestinian or Israeli provider and having a bathroom and a toilet or both). Similar household assets that represented variability, when combined, were combined into one, denoting either one present in the household (internet by a Palestinian or Israeli provider). For the pairs of assets with similar functions and different values, I included those with higher value (mobile phones and LCD or LED TV) and excluded those with less value (phone and conventional TV).

Other assets with similar functions and, when combined, still presented variability, I combined the two assets into one (air condition units and central air conditioners, iPad and tablets, and personal computers and laptops), which denoted either one of these assets were owned.

Table 5-4 presents the 13 household assets. I used these assets to create the assets scale described in the following section.

Table 5-4: Descriptive statistics of household assets of 19074 households in the twin cities of Ramallah and Albireh

	Item	Number of households that own the item	Percentage of households that own the item
1	freezer	4640	24.4%
2	vacuum cleaner	14893	78.2%
3	microwave	13895	72.9%
4	drying machine (tumble dryer)	5322	27.9%
5	dishwasher machine	5360	28.1%
6	water filter	4428	23.25%
7	LCD or LED TV	17319	90.8%
8	central heating	3790	19.9%
9	home library	5721	30.0%
10	internet line	16861	83.3%
11	Tablet/iPad	7675	40.3%
12	Laptop/PC	12951	68.0%
13	Air conditioning	7465	39.2%

5.3.2.2 Creating a household asset scale using principal component analysis

I considered two common approaches to combine the thirteen household asset variables into a single indicator. One way is simply calculating the sum of scores from each item to compute a total asset score. However, the limitation of this approach is that each item will have the same weight, which they don't in real terms assessments of affluence [12]. The other more comprehensive method

[12] Noting that the scale using the sum of scores had a mean of 6.4 and range 0-13.

combines the individual assets into a composite scale while assigning an appropriate weighting for each household asset.

One of the most common statistical methods of combining variables into a weighted scale is principal component analysis (PCA) (Kolenikov and Angeles, 2009; Poirier, Grépin and Grignon, 2020). PCA is an adaptive data analysis technique that reduces the dimensionality of the data by creating linear functions from the original variables. These linear functions are not correlated with each other, which consecutively expands the variance by rotating variables in the multi-variate space (Jolliffe and Cadima, 2016). The directions with the most significant variability in the matrix form the first component, which is the most informative in explaining the variability in the data.

The approach I applied to create a household assets scale was inspired by the methodology used to create the Demographic and Health Surveys (DHS) wealth index (Rutstein and Johnson, 2004; Rutstein, 2015). However, it was slightly amended by a more robust statistical technique. This section will discuss the methodology of constructing the household assets scale. It has three subsections that correspond to the three steps adopted to create the household assets scale:

1. Create a correlation matrix.

2. Examine the number of components the data constitute.

3. Use the matrix in PCA to obtain patterns of weights or loadings for the principal component.

5.3.2.2.1 The tetrachoric correlation matrix

In its basic form, PCA relies on the linear combination of variables in the covariance matrix (the multi-variate space). Another similar form of PCA is when the original variables are standardised (mean centred and divided by the standard deviation), for example, to account for the units of measurement. In this case, the PCA uses a standardised data matrix, also referred to as the correlation matrix PCA (Jolliffe and Cadima, 2016). The correlation matrix is ideally suitable for continuous, normally distributed data that form a continuity for a component to be detected.

Scholars argued that applying linear PCA on discrete data, such as in the DHS wealth index and this research, produces misleading estimations because the covariance (or correlation matrix) does not represent the "true" covariance (or correlations) between these variables (Kolenikov and Angeles, 2004; Basto and Pereira, 2012). Therefore, because of the binary nature of the household assets variables, standard linear PCA is not ideal for creating the household assets scale.

Alternatively, one proposed solution to this problem is to use the tetrachoric correlation matrix, which produces coefficients based on the maximum likelihood estimates of Pearson's correlation, assuming normal distribution (Kolenikov and Angeles, 2009). Developed by Pearson (1901a), the creator of PCA, the tetrachoric correlation matrix is a more specialised type of polychoric correlation matrix that suits ordinal data. The tetrachoric correlation estimates assume that the binary variables latently underlie unobserved normal continuous data. Therefore, using the tetrachoric correlation matrix for the binary variables in the PCA produces more accurate weights and more consistent estimates of the explained variance proportions than using linear correlation PCA (Drasgow, 2006; Kolenikov and Angeles, 2009; Basto and Pereira, 2012; Debelak and Tran, 2013). Furthermore, the tetrachoric correlation matrix allows the PCA to account for both having and not having the asset by the household. This is useful because not having the asset is also informative.

Accordingly, I produced the tetrachoric correlation matrix with inference from Pearson correlation. The tetrachoric correlation matrix had a good internal consistency, with Cronbach alpha equal to 91%, which indicates that the items in the matrix were closely related (Gadermann, Guhn and Zumbo, 2012). Figure 5-15 shows the heat map for the correlation matrix. The values range from -1 to 1, where 1 is the total positive correlation, and -1 is the total negative correlation.

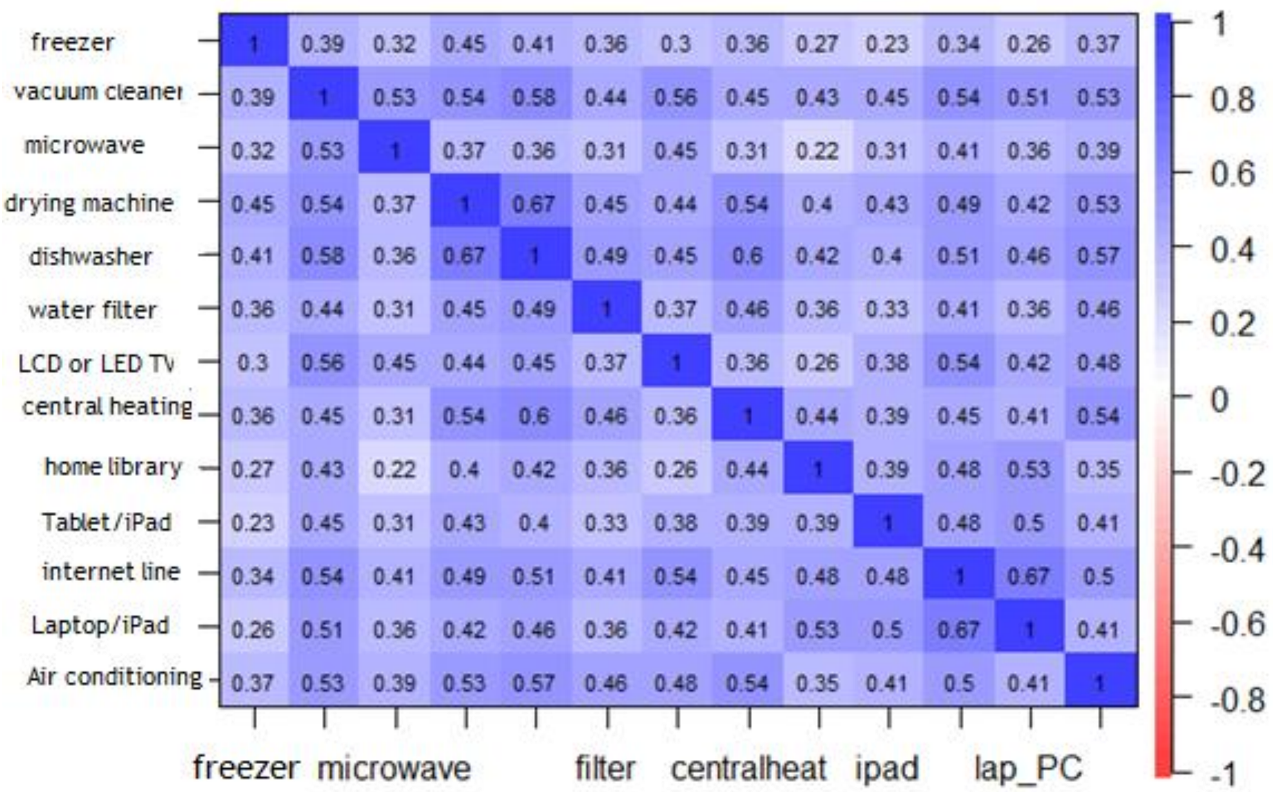

Figure 5-15: Heat map of the tetrachoric correlation matrix

5.3.2.2.2 <u>An exploratory technique to visualise the number of components that describe the variables</u>

Horn's parallel analysis is a common and accurate statistical method to examine and visualise the number of components the variables form (Horn, 1965; Garrido, Abad and Ponsoda, 2012; Debelak and Tran, 2013). Thus, I conducted a parallel analysis to investigate the number of components the household assets variables produce. This helped me to decide on the number of principal components to retain in the PCA.

I produced a scree plot of the parallel analysis, which showed the principal components (Figure 5-16). It examines the eigenvalues[13] with the quantiles of the distribution of the eigenvalues obtained from the parallel analysis. The scree plot in Figure 5-16 shows two distinguished principal components above the mean. However, the first component was more dominant, with an eigenvalue equal to

[13] Eigenvalues refers to the explained variance by each principal component.

6.22, compared to the marginally significant second component, with an eigenvalue equal to 1.1 (0.1 above the mean). Therefore, the parallel analysis confirms one principal component that will be retained in the PCA (Timmerman and Lorenzo-Seva, 2011).

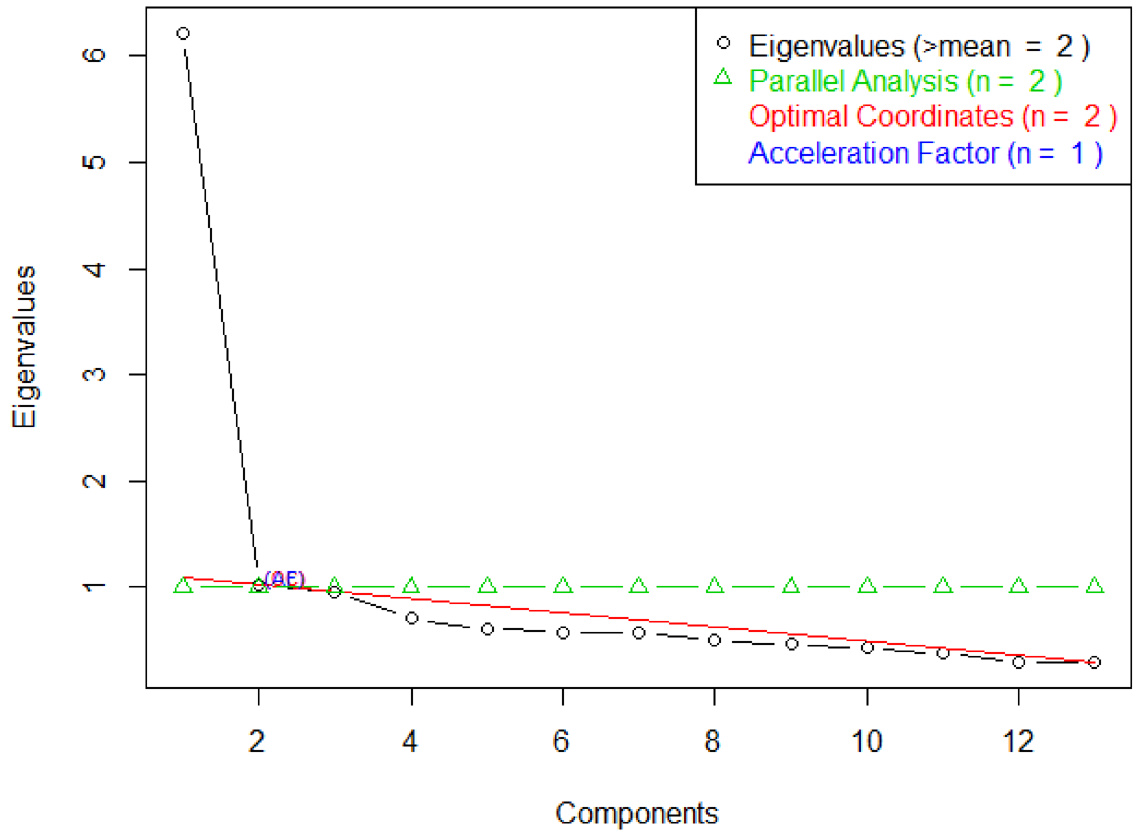

Figure 5-16: Parallel analysis test to determine the number of factors

5.3.2.2.3 Principal component analysis

I ran the principal component analysis on the tetrachoric correlation matrix. I retained only the first component, as confirmed by the parallel analysis. The proportion of the total variance explained by the principal component was 48%. Table 5-5 presents the standardised loadings or weights for each asset. Each household in the sample was assigned a score that summarised the 13 original assets while accounting for each asset's weight. Finally, I created a new continuous variable from the combined scores, which ranks the household wealth based on the owned assets by the household. A description of the household assets scale will be presented in chapter seven.

Table 5-5: The standardised loadings of assets based on the tetrachoric correlation

Freezer	0.55
Vacuum	0.78
Microwave	0.59
Drying machine	0.78
Dishwashing machine	0.78
Water filter	0.64
Flat-screen TV	0.67
Central heating	0.71
Home Library	0.61
Tablet/iPad	0.63
Internet	0.77
Laptop/PC	0.71
Air conditioning	0.74

5.3.3 Area-level variables

This thesis will investigate three area-level indicators of the twin cities of Ramallah and Albireh. These were the locality, political land classification, and urban green space. Within this section, I present these indicators, describe the variables they defined and how I constructed them, and show maps of the distribution of these variables in the enumeration areas of the twin cities.

5.3.3.1 Locality

The locality identifies the boundaries of the administrative or municipal management body. There are four localities in the twin cities: Ramallah, Albireh and the two refugee camps. I used the locality boundaries obtained from the PCBS (Figure 5-1) to define the locality of each enumeration area as belonging to either Ramallah or Albireh or a refugee camp. Thus, the locality variable has three categories describing each enumeration area's locality. The 228 enumeration areas were distributed as follows: 105 for Ramallah, 113 for Albireh, and 10 for the refugee camps (8 for Al Amari refugee camp and 2 for Qadoora refugee camp).

5.3.3.2 Political land classification

To create the political classification variable, I assigned a political land classification A, B, and C for each enumeration area. This was achieved by overlaying the pollical land classification layer obtained from the ministry of local government (Figure 4-5) with the map of the enumeration areas obtained from the PCBS (Figure 5-1). The intersection of these layers defined the political land classification of each enumeration area, as shown in Figure 5-17.

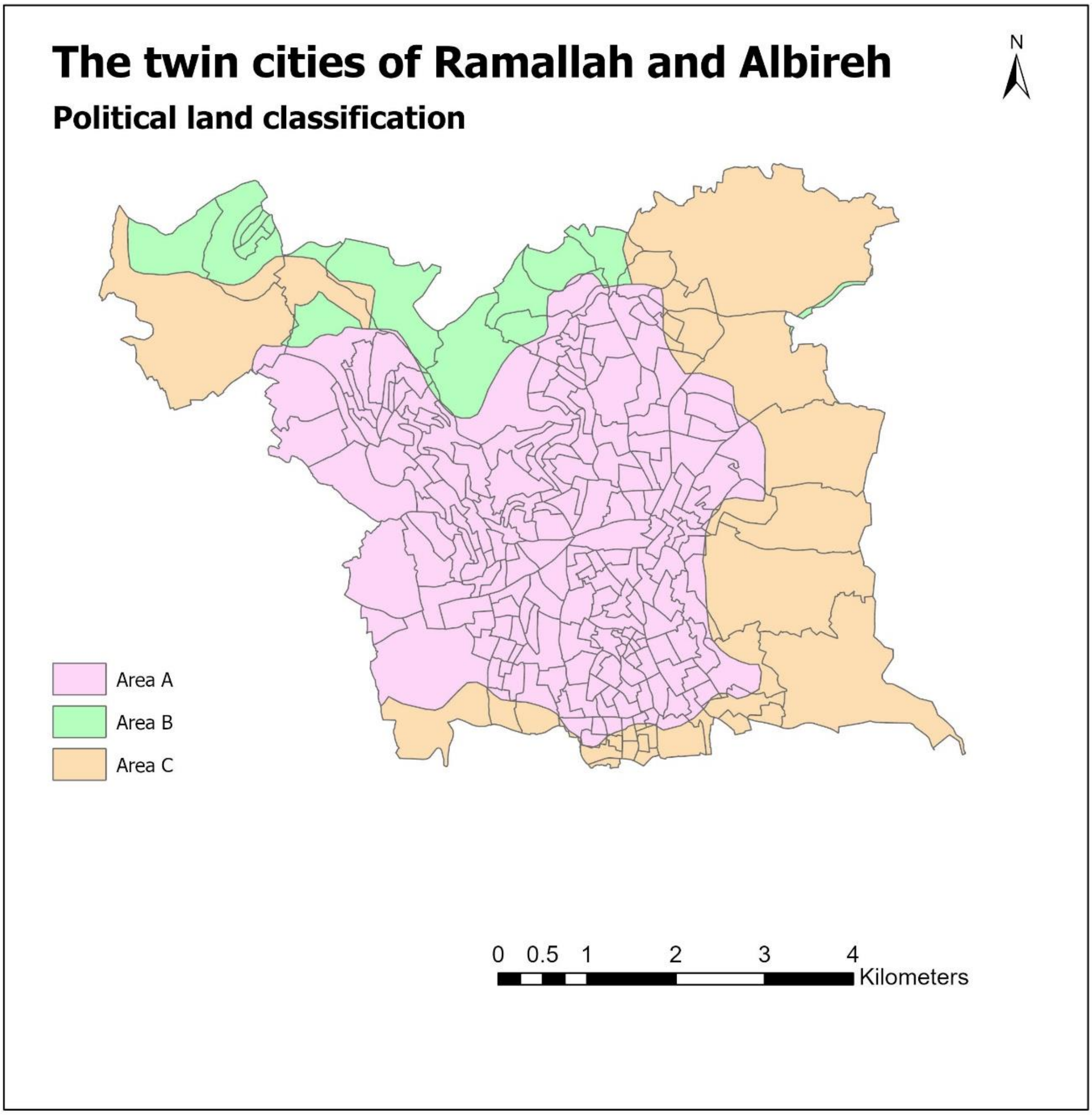

Figure 5-17: Political land classification in the enumeration areas

The political land classification boundaries did not completely align with all the enumeration area boundaries. Of the 228 enumeration areas, 184 were within a single political land classification boundary; 39 enumeration areas overlapped two different political land classifications, and 5 overlapped three. Therefore, I assigned enumeration areas to the political classification that constituted the dominant proportion of its area (more than 50%). For example, an enumeration area where 60% of the polygon was within the political land classification 'Area A' was subsequently assigned to 'Area A'. Thus, this approach assigned each enumeration area to one of the three political land classifications.

Because just 11 (of the 228) enumeration areas were classified as 'Area B', I combined 'Area A' and 'Area B' in one category, referring to areas governed by the Palestinian authorities. In contrast to the more disadvantaged areas that are politically classified as 'Area C', governed by Israeli authorities. Thus, the political classification variable was a binary variable where (one) indicated 'Area C' and (zero) indicated either 'Area A' or 'Area B'.

5.3.3.3 Urban green space

I created a green space variable to describe the proportion of each green space type within enumeration areas. I achieved this by overlaying and intersecting the map of the enumeration areas (shown in Figure 5-1) with the green space land cover map (shown in Figure 5-13). I calculated the area size for each land cover category in each enumeration area. Finally, I calculated the proportion of each land cover category in the enumeration areas by dividing their area size by the total size of each enumeration area.

For the analysis of this research, I created three new green space variables from the land cover data:

1. ***Open space*** is the land containing 'open space with little or no vegetation', 'arable land', 'sports fields', and 'shrub and/or herbaceous areas').

2. ***Mixed trees*** refer to the land containing coniferous and heterogenous trees.

3. ***Permanent crop trees*** refer to the land contacting only crop trees (mainly olive).

The rationale for creating three green space variables was that some of the lower-level green spaces were sparse for the entire study area. Three reasons supported the decision to combine open space categories: first, they were similar as they did not include trees. Second, the land cover categories of 'sports fields' and 'shrub and/or herbaceous areas' were considerably sparse. Three, as mentioned earlier in this chapter, there was some degree of uncertainty in mapping herbaceous vegetation and small shrubs, as they belong to open spaces with little or no vegetation' or 'shrub and/or herbaceous areas' because the former often contain herbs and small shrubs. Thus, combining those categories remove this uncertainty.

The land covered with trees was differentiated from the open spaces via two separate categories for trees. As demonstrated in the literature review chapter, trees have distinct qualities over other types of land cover with a more potential impact on the health and well-being of the population. Crop trees were not combined with mixed trees because of the difference in structure and accessibility compared to the mixed trees category. Crop trees are relatively small and are found mainly in less accessible areas. Below, Figure 5-18, Figure 5-19, and Figure 5-20 are the maps of the three green space variables used in the analysis, showing each variable's proportion in the twin cities' enumeration areas. The maps for each land cover category before combining similar types are presented in AppendixE D.

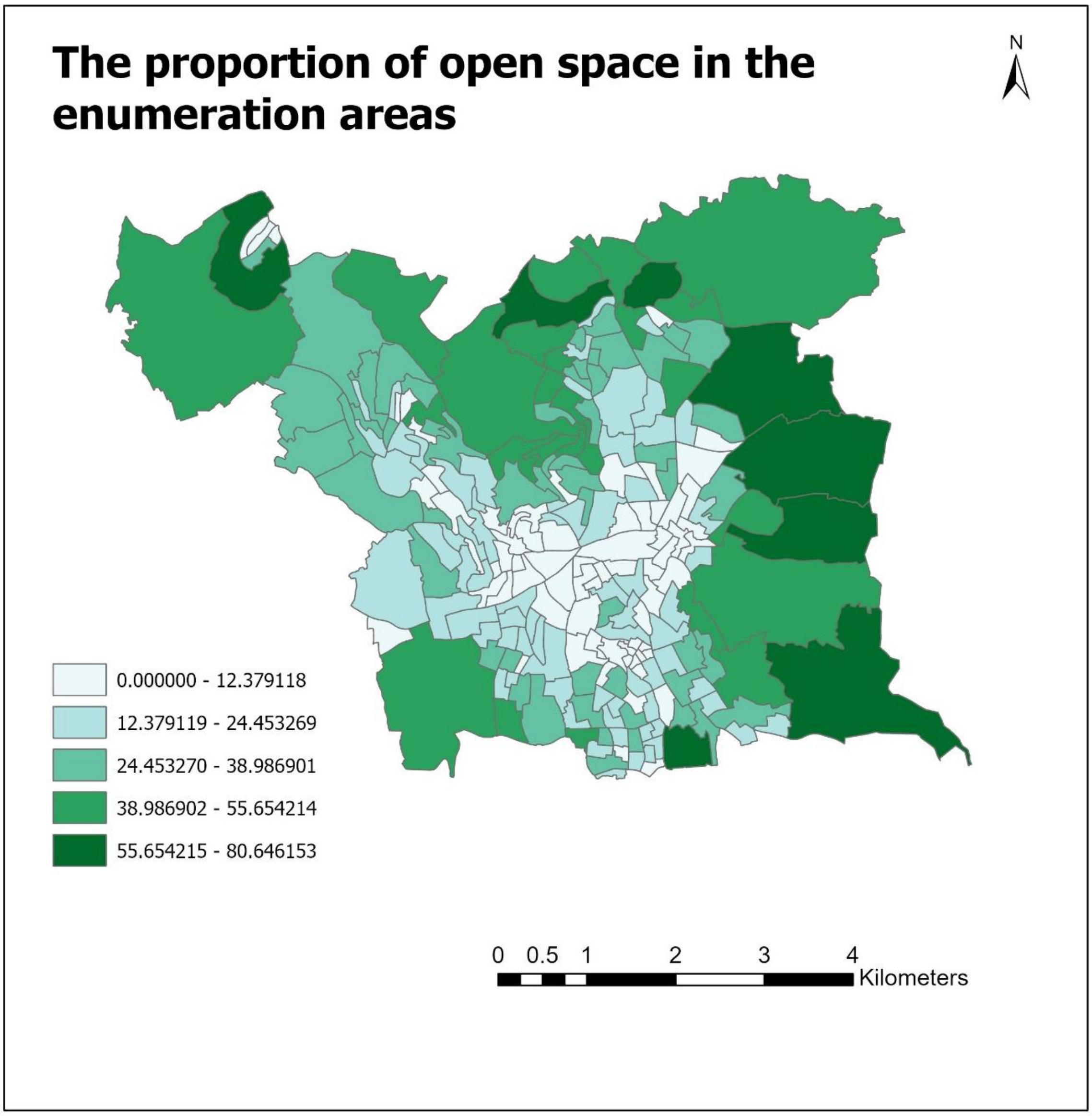

Figure 5-18: The proportion of open space in the enumeration areas of the twin cities

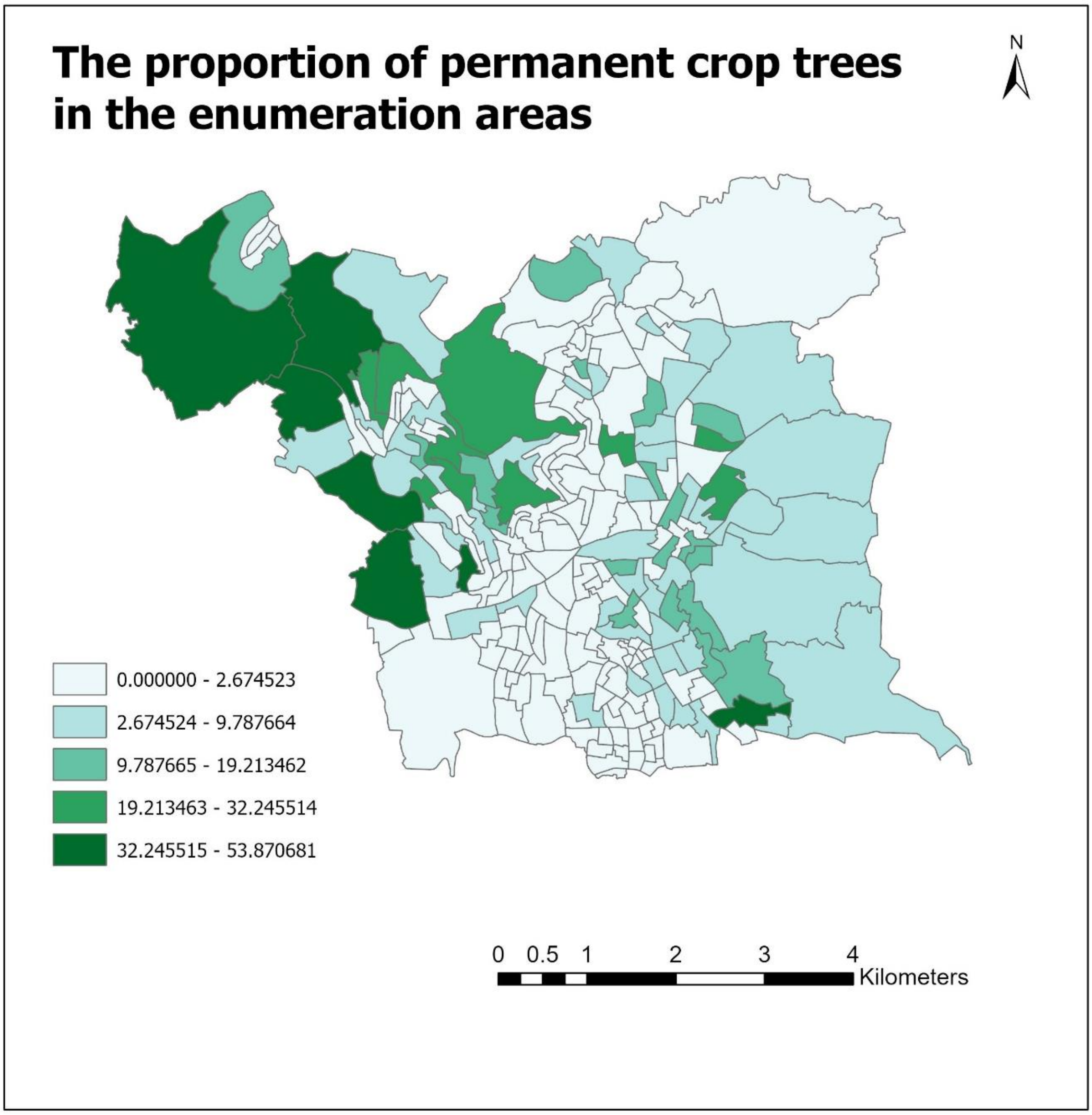

Figure 5-19: The proportion of permanent crop trees in the enumeration areas of the twin cities

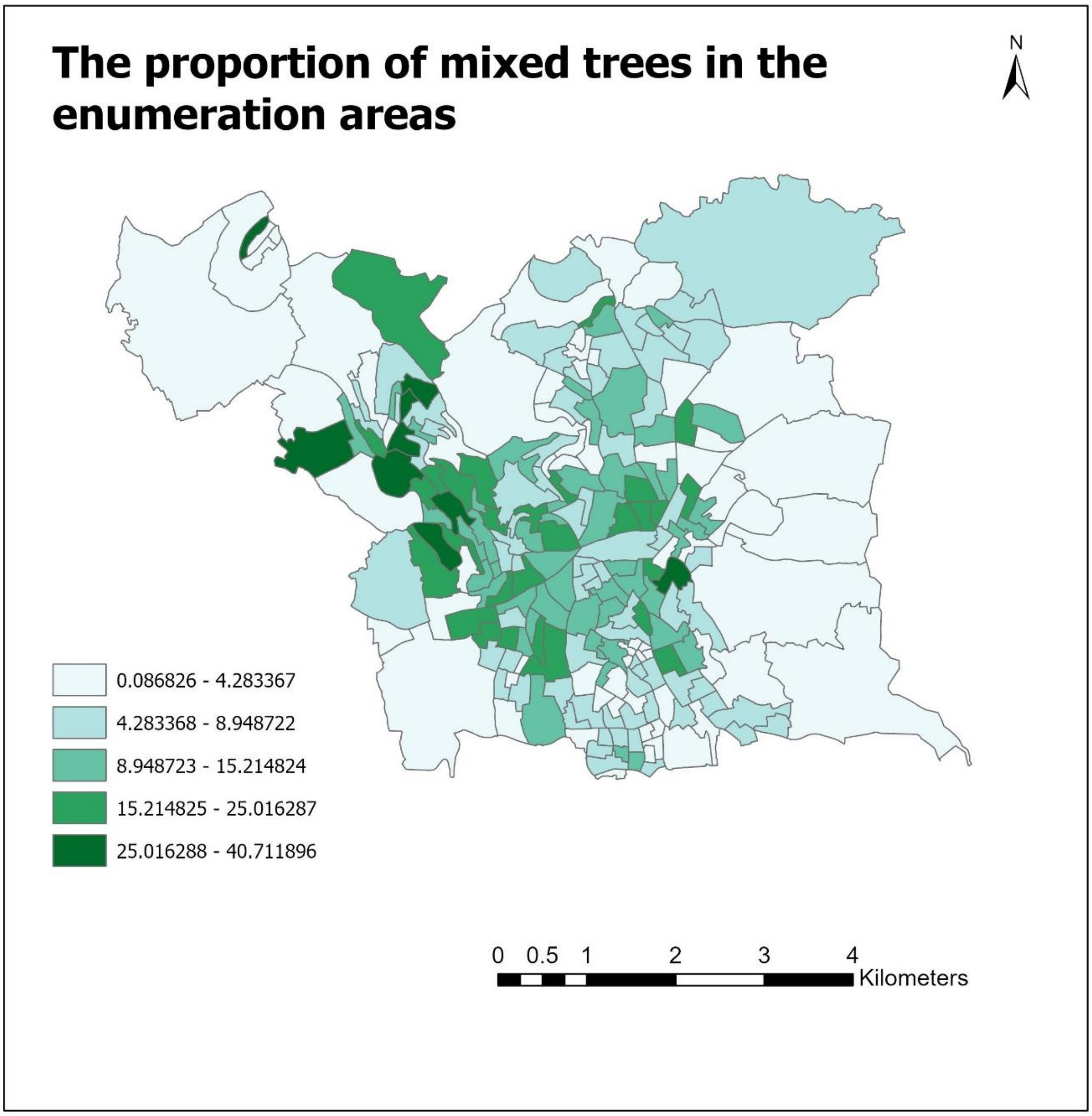

Figure 5-20: The proportion of mixed trees in the enumeration areas of the twin cities

5.4 Conclusion

This chapter discussed the data sources I drew on, the variables and spatial layers obtained, the checks and edits undertaken, and the rendering to a common spatial scale. In the first section, I described the PCBS 2017 census data and its administrative boundaries, which were the sources of individual and household-level information about the population of the twin cities of Ramallah and Albireh. The main strengths of the 2017 census data are that it represents the twin cities' whole population and has a meagre non-response rate. However, one weakness was that the few non-responses were not missing completely at random. I stated that in this thesis, I am using the 2017 census enumeration areas as the boundaries of the areas of residence. Then I presented the 2017 census variables used in the analysis and explained the process of choosing these variables. The individual and household level control variables were age, sex, years of residence, refugee status, health insurance, participation in the labour force, educational attainment, marital status, residential type, tenure, and household assets and technology usage. I selected one health outcome variable, chronic illness and explained that this was the best and only viable option to use as an outcome variable in my current research. It was sufficiently distributed across the population of the twin cities.

In the second section, I described the different GIS data sources for the twin cities of Ramallah and Albireh. I started with data from the ministry of local government, which provided information about the political land classification and a high-resolution map of the twin cities, which facilitated fine-scale editing of land cover data. Then I presented the GIS data obtained from the municipalities, the problems they included, and the data about buildings and streets from the municipalities that helped me edit the green space data. Finally, I discussed the land cover data obtained from ARIJ and its strengths, problems, and weaknesses. I explained that it needed editing to ensure the good quality of the land cover data. Then, I described the methodology of editing the land cover data from ARIJ and the final data that will be used in the analysis of this thesis.

In the third section of this chapter, I explained the process of preparing and calculating the variables at the individual, household, and area levels to be ready for use in the analysis.

In the following chapter, I will present the specific research questions in this thesis and discuss the methods I employed to answer them.

Chapter six: Research questions and statistical methods

In the previous chapter, I described the data I obtained and prepared to achieve the thesis objectives and the health outcome I will use in this research. In this chapter, I will set out the specific research questions of the thesis and then describe the multi-level statistical methods used to answer these research questions.

6.1 Research questions

This research will have two analyses which will address nine research questions. The first analysis answers six questions about the general contextual effects and associations between area-level variables and chronic illness. The second analysis answers three questions about the interaction between area-level and individual-level characteristics in their association with chronic illness.

Study one will answer the following questions:

1. How important is the context of residential areas, as defined by the boundaries of the enumeration areas, for the risk of chronic illness in the twin cities?

2. What is the relationship between living in the context of a refugee camp and the risk of chronic illness?

3. What is the relationship between living in the context of areas politically classified as 'Area C' and the risk of chronic illness?

4. What is the relationship between the proportion of 'mixed trees' in the areas of residence and the risk of chronic illness?

5. What is the relationship between the proportion of 'crop trees' in the areas of residence and the risk of chronic illness?

6. What is the relationship between the proportion of 'open space with little or no vegetation' in the areas of residence and the risk of chronic illness?

Study two will answer the following questions:

7. Does living in the context of refugee camps interact with age, sex, and socio-economic status in its association with chronic illness?

8. Does living in the context of areas politically classified 'Area C' interact with age, sex, and socio-economic status in its association with chronic illness?

9. Does the proportion of green space in the areas of residence interact with age, sex, and socio-economic status in its association with chronic illness?

6.2 Multi-level statistical analysis and modelling

This section details the multi-level statistical analysis performed to answer the research questions. In chapter two, I briefly introduced the multi-level approach, which allows investigation of the relationship between the characteristics of places and people's health while simultaneously accounting for the characteristics of people. I also discussed some of its main shortcomings for investigating place-based effects on health.

In this section, I will discuss multi-level regression modelling in more detail. First, I will start by describing the multi-level methods and their value as a tool that effectively deals with data structured at multiple levels. Second, I will discuss the generalised linear regression framework that suits the binary outcome measure in this research. Third, I set out the number of levels adopted in the multi-level generalised linear regression analysis. Fourth, I will explain the multi-level logistic regression models that I used in the analysis of this research, their equations, and their interpretations. Finally, I will discuss the measures I used, the estimation method of the models, the post hoc testing and quality checking of the models, the centring of variables, the modelling strategy, and the presentation of the results.

6.2.1 Multi-level methods

Multi-level methods[14] are statistical approaches used to investigate and answer questions related to the association between group-level characteristics and individual-level outcomes (Diez Roux, 2002; Kawachi, Subramanian and Almeida-Filho, 2002; Leyland and Groenewegen, 2020). They work by modelling the variables at different levels simultaneously while maintaining the multi-level structure of the data (Hox, Moerbeek and van de Schoot, 2010a; Owen, Harris and Jones, 2016). A primary value of the multi-level approach is that it allows for the decomposition of variation in the outcome for each hierarchical level and is flexible to a variety of hierarchical structures and eco-social models of health (Kearns and Moon, 2002). They overcome issues related to correlated data structures and dependencies that may arise in a single-level analysis (Hox, Moerbeek, & van de Schoot, 2010b; Smith & Easterlow, 2005).

The dependence problem is that people in the same group or living in the same areas are more likely to have shared characteristics, behaviours, and exposures different from those in other groups or areas. Thus, to a certain extent, people depend on their area or group. Not accounting for this dependence violates a basic and important standard regression assumption, which assumes that observations are not systematically related. The violation of the independence assumption might lead to autocorrelation problems and type I error (rejecting the null hypothesis when it is true). It leads to biases in the estimated regression coefficients and standard errors and makes it prone to incorrect inferences (Hox, Moerbeek and van de Schoot, 2010a; Zuur, Ieno and Elphick, 2010).

Moreover, and related to the objectives of this thesis, multi-level models do not only account for the dependence problem but quantify it by directly investigating

[14] Multi-level models are also referred to by different names such as hierarchal, mixed-effects, random effects, variance components and contextual methods

the correlation structure within and between clusters and how much the variables of interest explain the variability at all levels (Austin & Merlo, 2017).

In another domain, single-level regression can only infer associations on the same level; otherwise, the conclusions are not accurate, referred to as “fallacies of the wrong level”. Drawing conclusions from individual-level models about associations at the group level is called the atomistic fallacy. Drawing conclusions from an ecological analysis about associations at the individual level is called the ecological fallacy (Diez-Roux, 1998; Duncan, Jones and Moon, 1998). Multi-level models help avoid these fallacies by capturing the effects specific to each level. A further useful quality unique to multi-level methods is that they can allow examination of the interaction between higher-level and lower-level variables, called the cross-level interaction effect. Single-level regression models and tools adapted to account for the hierarchical data structure do not have this quality (Oakes, 2004).

6.2.2 The generalised linear regression framework

The observed outcome in this research (chronic illness) was a binary variable numerically described with two values, 1 for the presence of chronic illness and 0 for the absence of chronic illness. Regression models can be used to model binary variables. However, conventional linear regression is problematic because binary variables are restricted between zero and one (i.e., they are not continuous) and have a probability distribution rather than a normal distribution. These properties violate essential linear regression assumptions, and no empirical transformation of the binary data can normalise a probability distribution (Hox, Moerbeek and van de Schoot, 2010c). The generalised linear regression approach addresses these problems.

Generalised linear regression is an approach that incorporates necessary transformation and allows for error distributions other than a normal distribution within the statistical model (Hox, Moerbeek and van de Schoot, 2010c). Three components define it:

- A customary 'non-linear' link function.

- A structural element (or linear predictor).
- An outcome variable with a specific error distribution with a mean μ and variance σ^2.

A basic generalised linear regression model equation looks like this:

$$g(\mu) = \beta_0 + \beta_1 x \quad 1$$

Here g() is the link function and $\beta_0 + \beta_1 x$ is the structural component. The generalised linear regression works by linking the covariates' predicted values that have a normal distribution with the expected probability that has a non-normal distribution. The link function serves this purpose while simultaneously being separated from the error distribution. The estimation is achieved through maximum likelihood, which involves capturing the probability distribution and model coefficients that best describe the observed data.

6.2.2.1 Logistic regression

Logistic regression is one type of generalised linear regression suitable and commonly used for binary outcome data. Other types of generalised linear regression also suit binary data, such as the 'probit' regression, but logistic regression is more widely used and has the advantage that the log-odds estimates can be exponentiated and interpreted as odds ratios (Zuur *et al.*, 2009; Hox, Moerbeek and van de Schoot, 2010b). Logistic regression uses the logit link function. The logit link function for the probability (p) is:

$$logit(p) = ln(p/(1-p)) \quad 2$$

In the generalised linear regression framework, the logistic regression models use the inverse of the logit link function (the logistic) to transform the predicted values (ranging from $-\infty\ to\ +\infty$) to values that range from 0 to 1, denoting the predicted probabilities.

Below I introduce single-level logistic regression. By doing so, I will be better able to highlight the difference between single-level and multi-level logistic regression models in subsequent sections. In single-level logistic regression, with the probability that the outcome y_i equal one is π_i, and y_i have a Binomial distribution, and because it has only one possible outcome (0 or 1), it can be expressed as:

$$y_i \sim Binomial\ (1, \pi_i)$$

Using only one explanatory variable x_i the logistic regression equation for π_i is:

$$\pi_i = logistic\ (\beta_0 + \beta_1 x_i) \qquad 3$$

As mentioned above, π_i is the outcome that y_i equal to one and have a Bernoulli distribution[15]. The average intercept is β_0 and $\beta_1$is the slope of x_i. The logistic function transforms the predicted values to values between zero and one. Both β_0 and β_1 are measured by the log odds, and exponentiating these values will give the odds ratio $\pi_i\ /(1 - \pi_i)$.

Since multi-level model equations will depend on the data structure, the following section will first address the data structure of the current research and the number of levels adopted in the analysis.

6.2.3 The data structure used in the analysis

The data structure in this research was in three levels of hierarchy, individuals (54693) nested within households (18522) within enumeration areas (228). However, for analysis, I needed to re-structure them into two levels (individuals and enumeration areas). There were three problems with including households as a separate level. First, in multi-level models, the effects of clusters (i.e., households and areas) on the outcome are treated as random and assumed to follow "approximately" a bivariate normal distribution (De Leeuw and Meijer, 2008). After examining the clustering effect of the households, it revealed a distribution closer to quadratic than a normal distribution (Figure 6-1), thus violating the

[15] Bernoulli distribution is a special case of binomial distribution of proportions where the data refer to only one response (or one trial), thus the denominator of the proportion is equal to one.

normality assumption of the clustering effect.

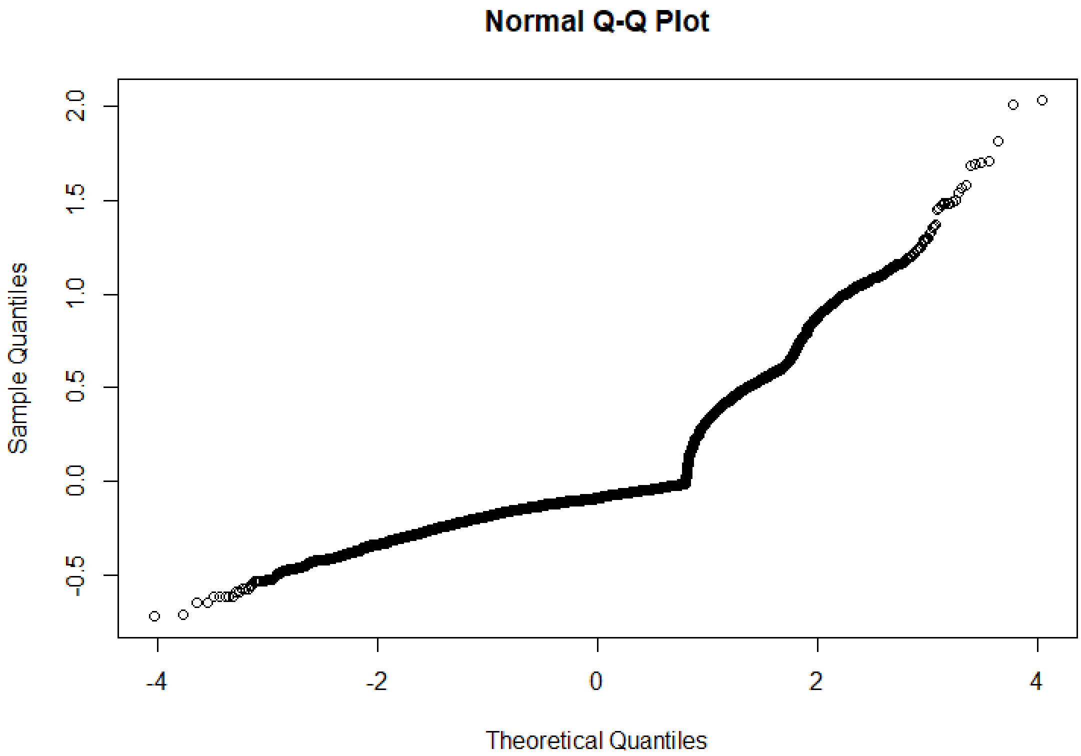

Figure 6-1: distribution of the household level random effect

Second, because the outcome in this research was not linear, the estimation in the multi-level models was based on the maximum likelihood method. The low number of individuals per household (average 3.4) was problematic for this estimation method, especially for random slope models; ideally, it requires clusters with more than 25 lower-level units (Duncan, Jones and Moon, 1998). Thus, it might lead to poor estimation, slow and demanding computation and a higher likelihood of convergence problems (Tuerlinckx *et al.*, 2006; Josephy, Loeys and Rosseel, 2016). Third, a large number of households with insufficient observations within them would seriously complicate any further data analysis (such as cross-level interactions) (Raudenbush, 2008).

In summary, including a separate level for households would have led to unstable models and poor estimation. Given that the main interest in this thesis was the area-level influence, the data were re-structured into two levels; level one was individuals, and level two was enumeration areas. Adopting this structure transferred the variance at the household level to the individual level. Had the household level been a substantive research interest, other methods could have been used, such as a Bayesian framework (Josephy, Loeys and Rosseel, 2016).

6.2.4 Multi-level logistic regression models

In the two-level hierarchical structure, the observed binary outcome of chronic illness is denoted by y_{ij} where an individual (i) is within an enumeration area (j). The multi-level logistic regression models the probability of an individual (i) in enumeration area j having a chronic illness $(y_{ij} = 1)$ denoted by π_{ij} that has a Binomial distribution.

$$y_{ij} \sim Binomial\ (1, \pi_{ij}) \qquad 4$$

The multi-level logistic regression works by modelling the transformed probability π_{ij} as a linear combination of the explanatory variables and the random or area effects.

This section will describe the multi-level models used in this research. First, I will present the models for study one that seeks to quantify the area effect on the risk of chronic illness and the area-level variables that might be associated with the risk of chronic illness (research questions 1-6). I will start with the simplest empty (null) model and then build on it by adding predictors at the two levels. Then, I will increase the complexity of the multi-level models and explain the models for study two that sought to investigate the interaction between individual-level and area-level characteristics in their relationship with the risk of chronic illness (research questions 6-9). Here, I will describe the random slope model and the model with cross-level interaction terms answering research questions 6-9.

6.2.4.1 The null model

The main idea in the multi-level regression equations is that the average intercept (and slope), which are assumed to be fixed in a single-level regression, are allowed to be at random for each higher-level unit or area. It can be conceptualised as an individual-level regression that corresponds to individuals within areas, which then feeds into another model that corresponds to the area level.

The multi-level logistic model without explanatory variables is called the empty or the null model. It is the simplest multi-level model which shows the random variation of the outcome between and within clusters or areas without accounting for explanatory variables at any level (Snijders and Bosker, 2012). Comparing models with explanatory variables to the null model provides information on the extent to which these variables explain the variability in the outcome between and within areas.

The level-one null model equation represents the logistic regression for individuals within areas. Thus, the level one logistic regression equation is:

$$\pi_{ij} = logistic\ (\beta_{0j}) \qquad 5$$

The intercept β_{0j} is the estimated average 'log odds' of chronic illness of the individuals in enumeration area j. In the multi-level framework β_{0j} can be considered random across enumeration areas and assumed to be drawn from the population of enumeration areas. Hence, β_{0j} is treated as a 'latent' dependent variable and included in the level 2 equation predicting the average probability of chronic illness for each area j:

$$\beta_{oj} = \gamma_{00} + u_{0j} \qquad 6$$

The estimate γ_{00} is the estimated log-odds of chronic illness for an individual living in an average area. u_{0j} is the residual error term or the random 'area' effect quantifying the deviations (in the outcome) of area j from the average of all the enumeration areas. Under the assumption that the sample of enumeration areas is taken from the population of enumeration areas, u_{0j} is an independent random variable that has a normal distribution with mean zero and variance τ_0^2.

$$u_{0j} \sim N\ (0, \tau_0^2) \qquad 7$$

Thus, the multi-level null model is a combination of the equations at the two levels, formulated as:

$$\pi_{ij} = logistic(\gamma_{00} + u_{0j}) \qquad 8$$

A two-level null model identifies the random 'area' effect denoted by u_{0j} and its variance.

6.2.4.2 Adding predictors to the null model

Predictor variables at the two levels can then be added to the null model. For demonstration purposes and simplicity, one variable from each level will be added to the equation above: a level one variable x_{ij} (the individual level), and a level two variable z_j (at the area level). Adding these variables to the null model, the equation becomes as follows:

$$\pi_{ij} = logistic(\gamma_{00} + \gamma_{10}x_{ij} + \gamma_{01}z_j + u_{0j}) \qquad 9$$

The intercept γ_{00} represents the log-odds for individuals in an average area and γ_{10} and γ_{01} are the average effects/slopes of x_{ij} and z_j respectively on the outcome. These constitute the fixed part of the equation that specifies the overall average relationship between the outcome and the explanatory variables. The random part u_{0j} represents the deviations of areas from the overall average. The between area variance τ_0^2 in the unexplained area residuals (u_{0j}) quantify the variation in the outcome at the area level that is unexplained by the explanatory variables included in the model.

This model estimates the probability of an individual having a chronic illness that is dependent on the explanatory variables added to the model *and* on the area effect u_{0j}. Assuming that x_{ij} and z_j are continuous variables: γ_{10} estimates the effect on y_{ij} by a one-unit change in x_{ij} while holding other variables and area average probability of chronic illness constant. This interpretation also applies to γ_{01}.

6.2.4.3 Random slope model

Modelling individual and area-level explanatory variables in random intercept models estimates the association between these variables and the outcome while accounting for (and calculating) the area effect on the outcome. These models are suitable for the research questions related to the general contextual effect and the association between the area-level characteristics and the probability of chronic illness (i.e., research questions 1-6).

For research questions related to cross-level interaction (7-9), random intercept-only models might be problematic because they assume that the associations between the individual-level variables and the outcome are fixed across areas. Forcing the associations to be fixed when they are not might induce specification errors (heteroskedasticity and autocorrelation) that could severely affect the estimates of both the interaction and the main effect involved in the cross-level interaction, thus leading to faulty statistical inference (Heisig and Schaeffer, 2019). Therefore, it is better to conduct a model with cross-level interaction terms while allowing the associations between individual-level variables and the outcome to be random at the area level, called the random slope model. In regression terms, the random slopes model allows each enumeration area to have its regression line determined by a unique intercept and slope for the individual-level variable of interest. Area-level variables slopes cannot be set as random because this requires another level higher than areas; locality had only three categories which was insufficient to be considered as a random effect.

Assuming that x_{ij} is the variable of interest to be included in the cross-level interaction, the random slope equation is an extension to equation (9) with the addition of a new term for the variable x_{ij} at the individual level, which allows association between x_{ij} and the outcome to vary between enumeration areas:

$$\pi_{ij} = logistic(\gamma_{00} + \gamma_{10}x_{ij} + \gamma_{01}z_j + u_{1j}x_{ij} + u_{0j}) \qquad 10$$

The only difference between this equation and equation (9) is the term $u_{1j}x_{ij}$, which represents the random slopes for the variable x_{ij}. The random slope term u_{1j} can be understood as the departure of the slope in each area from the average slope, thus, representing a latent random interaction between the enumeration areas and the variable x_{ij} (Snijders, 2012). The difference between the slopes of each area u_{1j} from the average slope is called the variance in slopes τ_{11}, which quantifies the amount of heterogeneity in the random slopes across enumeration areas. A non-zero slope variance τ_{11} indicates that the slopes vary across areas, and its value assesses the extent to which the association between x_{ij} and the outcome varies across areas.

6.2.4.4 The model with cross-level interaction

The cross-level interaction term between the individual-level variable x_{ij} and the area-level variable z_J are added to the random slope model equation (10) above. The cross-level interaction term is expected to explain the variability in slopes between the individual-level variables and the outcome across enumeration areas. The equation for the cross-level interaction is:

$$\pi_{ij} = logistic(\gamma_{00} + \gamma_{10}x_{ij} + \gamma_{01}z_J + \gamma_{11}(x_{ij} * z_j) + u_{1j}x_{ij} + u_{0j}) \qquad 11$$

The estimate of γ_{11} is the cross-level interaction coefficient of x_{ij} and z_j estimates on the outcome. It estimates the magnitude of the association between the enumeration area-level variable z_j and the outcome y_{ij} change as a function of an individual-level variable x_{ij} and how much the magnitude of the association between individual-level variable x_{ij} and the outcome change as a function of an enumeration area-level variable z_j. As mentioned earlier, the variance (τ_{11}) across areas slopes of x_{ij} on π_{ij} is expected to reduce after the inclusion of the cross-level interaction term (Snijders and Bosker, 2012).

I will now explain how to interpret the estimates in equation (11) using example explanatory variables; age as a continuous individual-level variable (x_{ij}) and green space as a continuous area-level variable z_j. The intercept γ_{00} is the log-odds of poor health for individuals with zero-age and no green space in their enumeration areas. The estimate of the main effect of age γ_{10} is the log-odds for a one-year increase in age when green space is zero. The estimate of the main effect of green space γ_{01} is the log-odds of a one per cent increase in green space when age is equal to zero. Finally, the estimate of the cross-level interaction between age and green space (γ_{11}) measures the consequence of an increase by one unit for both age and green space. The interaction term γ_{11} is the difference between the log-odds corresponding in the increase of age by one year for two green space homogenous groups and the log-odds difference between increasing green space by one per cent for two homogenous groups that differ by one year in age.

For a categorical variable x_{ij}, for example, sex (male is the reference category) and continuous green space variable z_j, the interpretation is as follows. The intercept γ_{00} is the log-odds of poor health for males living in areas without green space. The main effect of sex γ_{10} is the log-odds of females living in areas without green space. The main effect of green space γ_{01} is the log-odds that correspond to a one per cent increase in green space proportion between males. The interaction effect γ_{11} is the expected log-odds difference for an additional one per cent increase in green space proportion for females versus males.

Finally, for two dummy variables included in the cross-level interaction, for example, sex (reference is males) and living in a refugee camp (reference is living outside refugee camps), the intercept γ_{00} is the log-odds for males outside refugee camps. The main effect of sex γ_{10} is the log-odds for females compared to males outside refugee camps. The main effect of refugee camps γ_{01} is the log-odds for living in refugee camps compared to living outside the refugee camps amongst males. The coefficient of the cross-level interaction γ_{11} measures the difference between the log-odds of females versus males living in refugee camps and the log-odds between females versus males living outside refugee camps.

The variables in the models will be centred. Hence, the zero value for the reference point will change according to the constant used in the centring. Later in this chapter, I will discuss the centring methods adopted in this analysis. In the following section, I will explain different approaches to measuring the contextual effect and the variance explained by the models in the context of multi-level logistic regression.

6.2.5 Quantifying the general contextual effect and the variance explained

There are two methods to quantify contextual effects on the risk of chronic illness in the multi-level logistic analysis (and therefore address the first research question): a variance partition coefficient (VPC) or the interclass correlation coefficient (ICC), and a median odds ratio (MOR). Both measures are reported in the models of study one in this thesis. I will first explain the VPC (or ICC) and the latent response concept, which facilitates estimating the variance at the individual level. I will then explain the MOR method to understand the magnitude of clustering and how it is interpreted. Finally, I will discuss the proportion change of the between-area variance and the total variance explained by the models, which will be used when comparing different models.

6.2.5.1 The variance partition coefficient (VPC) or the Interclass Correlation Coefficient (ICC)

The variance partition coefficient (VPC) measures the proportion of variance in the propensity of the dependent variable that is attributable to the higher-level units (areas) (Goldstein, Browne and Rasbash, 2002). For the data structure in this research, the VPC is equivalent to the interclass correlation coefficient (ICC), which refers to the correlation between two individuals living in the same enumeration area (Austin and Merlo, 2017). Thus, I will only use the term ICC for the rest of the thesis.

The ICC is a key concept in the multi-level methods, which estimates the general contextual effect or the effect of clustering (Austin and Merlo, 2017). When it is equal to or more than 2%, it indicates the presence of an area (or higher-level) effect and that a multi-level framework is a suitable approach (Raudenbush and Bryk, 2002).

The ICC is calculated by dividing the variance at the area level only (τ_0^2) by the total variance estimated at the two levels. The higher the ICC, the higher the general contextual effect. In conventional linear multi-level models, the ICC is directly estimated from the models. However, this is not the case for multi-level logistic models. As shown above, the logistic regression specification in modelling probability (π_{ij}) doesn't include a term for the variance of the residuals (or errors) at the individual level. In the binomial (and Bernoulli) distribution, the individual-level residuals are not normally distributed, and the variance of the error distribution is nonconstant and dependent on the transformed probability (π_{ij}), which is equal to $\pi_{ij}(1 - \pi_{ij})$. Therefore, in the logistic regression, the variance at the individual level cannot be estimated separately (Hox, Moerbeek and van de Schoot, 2010c).

One common approach to estimating the ICC in this situation is to formulate the logistic regression as a threshold (or a latent response) model. This method, developed by Goldstein et al.(2002), assumes that the dichotomous outcome is underlain by a latent 'unobserved' continuous variable. Under this assumption, an error term (ϵ_{ij}) is added to the logistic regression equation referring to the individual level residuals, that are assumed to follow a standard logistic distribution with mean zero and variance equal to $\pi^2/_3 \approx 3.29$ (De Leeuw and Meijer, 2008; Snijders and Bosker, 2012; Austin and Merlo, 2017). Thus, formulating the multi-level logistic regression as a threshold model, the ICC is equal to $\tau_0^2/(\tau_0^2 + \pi^2/_3)$.

Another measure for the contextual effect that intuitively interprets the binary outcome is the median odds ratio (MOR), discussed in the following section.

6.2.5.2 Median Odds Ratio (MOR)

The variance at the area level can be used to calculate the median odds ratio (MOR) introduced by Larsen & Merlo in 2005. The MOR converts the estimated variance into a measure on the well-known odds ratio scale, making it consistent, easily interpretable, and comparable to the odds ratios estimated for the models' coefficients. Therefore, MOR provides a practical inference on the magnitude to which the individuals' risk of chronic illness is attributed to the areas of residence (Merlo *et al.*, 2006; Leyland and Groenewegen, 2020).

The MOR is defined as: "the median value of the odds ratio between the area at highest risk and the area at lowest risk when randomly picking out two areas" (Merlo et al., 2006, page 292). Compared to the ICC, MOR only uses the variance between areas (τ_0^2), and is calculated as:

$$MOR = exp\,\{\sqrt{2 * \tau_0^2} * 0.6745\}$$

0.6745 is the 75th centile of the standard normal density of mean 0 and variance 1. MOR can be interpreted as follows: if an individual moves to an area with a higher risk of chronic illness, their probability of having a chronic illness will increase (in median) with the value of MOR.

The main benefit of using MOR is that it can be compared with the coefficients estimates (odds ratios) in the models. However, because the odds ratios can range from one to infinity and MOR only depends on the between area variance, it is suggested that the interpretation of MOR should be in parallel with the ICC, which estimates the clustering effect or the general contextual effect. For example, when the ICC is small, the MOR should be interpreted in the context of a small ICC (Austin and Merlo, 2017). Thus, both the ICC and the MOR are reported in the results of study one.

6.2.5.3 The proportion change of area variance and the total variance

The proportion of change in the area variance is a method to compare different models in terms of the variation they explain (Snijders, 2012; Austin and Merlo, 2017). For example, comparing the area variance for the null model (τ_{null}^2) with the area variance of the model after adding all the explanatory variables (τ_{full}^2), the proportional reduction in the between area variance is:

$$\frac{\tau_{null}^2 - \tau_{full}^2}{\tau_{null}^2} \qquad 12$$

However, in the context of the latent response model discussed above, the variance at the individual level-1 is fixed at $\pi^2/3$. This means that adding variables at the individual level will not reduce the individual-level variance. Thus, the area-level variance is rescaled to account for fixed variance at the individual level. Consequently, adding variables that explain the variance at the individual level will *increase* the variation at the area level. This might imply that the general contextual effect increased, but it is an artefact (Browne *et al.*, 2005; Snijders and Bosker, 2012). To quantify the proportion of explained variance at the higher level (after including individual-level explanatory variables), the between area variance should be rescaled to the variances in the null model. Adding variables at level 2 does not require rescaling, as these variables do not explain the between-individual variation. A variance rescaling method was proposed by Snijders & Bosker for logistic random intercept models (an extension of Mckelvey and Zavoina's method to calculate the pseudo R squared for non-linear single-level models). The rescaled variance components allow for appropriate comparison of the variance between models; therefore, appropriate assessment of the proportional change in the between-area variance between the null model and models with explanatory variables.

There are two measures of the *total* variance explained by the models. One is the total variance explained by the fixed effects, which is referred to as marginal R^2_{dicho}, defined by Snijders & Bosker (2012) as:

$$Marginal\ R^2_{dicho} = \frac{\sigma_f^2}{\sigma_f^2 + \tau_0^2 + \pi^2/3} \qquad 13$$

σ_f^2 is the variance of the linear predictor or the explained part of the total variance, and $\tau_0^2\ and\ \pi^2/3$ are the unexplained part of the total variance.

The other measure is the total variance explained by both the fixed and the random effects, referred to as conditional R^2_{dicho}, defined by Nakagawa & Schielzeth (2013) as:

$$Conditional\ R^2_{dicho} = \frac{\sigma_f^2+\tau_0^2}{\sigma_f^2+\tau_0^2+\pi^2/3} \quad 14$$

Both the conditional and the marginal total variance explained provide useful information about the models and are presented in the results. For more discussion about rescaling the between cluster variance and the total variance explained in the multi-level logistic regression, see: Snijders & Bosker (2012) pages 305-309, Hox et al. (2010b) pages 133-138 and Nakagawa and Schielzeth (2013).

6.2.6 Cluster-specific and population average estimates

Multi-level regression estimates of the association between explanatory variables and the outcome are conditional on the random effect, or cluster-specific. Thus, the estimates describe the association between the explanatory variable and the outcome for two individuals living in the same area. For the individual-level variables, the cluster-specific estimates have a clear interpretation. However, these estimates are less intuitive for the area-level variables because they have the same value within areas. Population average estimates (or marginal estimates) have a more straightforward and intuitive interpretation because they indicate the effect of the explanatory variable on individuals in different areas (Austin and Merlo, 2017).

The cluster-specific and population average estimates are identical in multi-level linear regression for a normally distributed outcome. However, they might differ in the logistic regression for binary outcomes (Austin and Merlo, 2017; Leyland and Groenewegen, 2020). Therefore, the population average odds ratios and confidence intervals are approximated from the multi-level models and reported in the results instead of the cluster-specific estimates. The approximation works by dividing the cluster-specific log-odds estimates of the multi-level logistic models by the shrinkage factor (Austin and Merlo, 2017):

$$\beta^* \approx \beta/\sqrt{1+0.346*\tau_0^2} \quad 15$$

β^* is the population average log-odds, β is the cluster-specific log-odds and τ_0^2 is the between-areas variance. The population average odds ratios compare two individuals from two different enumeration areas but share all other characteristics except the variable of interest.

6.2.7 Estimation used in the logistic multi-level regression models

There are several statistical software packages to estimate the parameters and fit a generalised linear multi-level model. These packages differ in terms of features and numerical and computational estimation methods. The generalised multi-level models' analysis of this research was run using the "Lme4" package in R data analysis software, which uses the Laplace approximation method of the maximum likelihood, with a bound optimisation of the constrained random effects (BOBYQA) (Bates *et al.*, 2020). I selected the Laplace approximation method of maximum likelihood because it is flexible to complex multi-level models, has acceptably accurate estimation, has an efficient and fast computation, is recommended by multi-level scholars and is the most widely used by researchers (Raudenbush, Yang and Yosef, 2000; Bolker *et al.*, 2009; Li *et al.*, 2011; Snijders and Bosker, 2012; Finch, Bolin and Kelley, 2015). For more information about the Laplace approximation method, see Raudenbush et al. (2000) and Bates et al. (2015).

6.2.8 Model checking

I conducted several tests to check that the multi-level logistics regression models were adequate and robust, such as the "goodness of fit" to the data, and that the models met the underlying assumptions. This section briefly presents these tests.

6.2.8.1 Testing the fixed and random effects parameters

Models fitted with different fixed and random effects were compared using the likelihood ratio or the deviance test: -2 times the loglikelihood ratio and its chi-square value. A significant fit was identified by a likelihood ratio test chi-square value of less than 0.05.

6.2.8.2 Multi-collinearity

To satisfy the assumption of no multi-collinearity between the variables, I tested the Variance Inflation Factor (VIF) for all the fixed effects in the models to ensure that the variables are not highly correlated (Fox and Weisberg, 2019). The tests indicated no high correlation between explanatory variables.

6.2.8.3 Normal distribution of the random effect

I visually tested the assumption that the random effect has a normal distribution by plotting the enumeration area effect (u_{0j}) against the standard quantiles (Lüdecke and Schwemmer, 2019). Figure 6-2 shows that the enumeration area effect fell roughly close to the diagonal line demonstrating normal distribution.

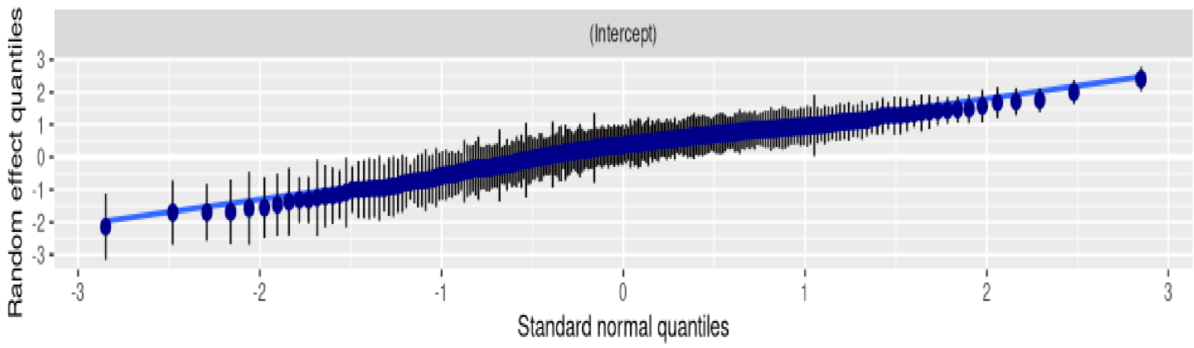

Figure 6-2: Random enumeration area effect QQ-plot

6.2.8.4 Multi-level logistic regression residual diagnostics

Standard (conventional) residual plots are not clearly informative and are limited in terms of investigating misspecification in generalised linear multi-level models (Pan and Lin, 2005). For that reason, the assessment of the models' residuals was via the simulation-based method in the "DHARMa" package in R. The "DHARMa" package simulates scaled residuals from fitted models and then examines their residuals' distribution (Hartig, 2020). This is like a Bayesian and parametric bootstrap approach, where the scaled residuals are standardised to fit between the values of 0 and 1. Simulation facilitates the interpretation of the residual patterns in multi-level logistic regression, like that in linear regression.

I examined the deviations of the simulated residuals from the expected distribution using the quantile-quantile (QQ) plot. I explored the simulated residuals using non-parametric statistical tests for outliers, deviation and dispersion and examined plots of scaled residuals against the predicted values to assess uniformity and pattern. Finally, I tested the quantile deviations of the simulated residuals against the observed residuals (Hartig, 2020). All these tests and plots revealed that the models were valid and correctly specified, presented in Appendix F.

6.2.9 Centring options for the data in the multi-level analysis

There are two options to centre the data in multi-level analysis; grand mean centring and cluster mean centring. The choice depends on the research question. The grand mean centring is appropriate when the interest is the influence of cluster-level variables on the outcome, whereby the level one covariates are used as control variables (Enders and Tofighi, 2007). When cross-level interactions are the main interest, some scholars recommend cluster mean centring, which distinguishes between the within and between cluster variation (Enders and Tofighi, 2007; Bell, Jones and Fairbrother, 2018). In this section, I will introduce both forms of centring and how they correspond to the research questions in this thesis. Then, I will discuss and justify the centring method adopted in this research.

6.2.9.1 Grand mean centring

The grand mean centring of the explanatory variables deviates these variables from their overall mean. For example, for a level one variable x_{ij}, grand mean centring subtracts the variable overall mean ($\bar{x}_{.}$) from each score on that variable; thus, the transformed variable will be equal to ($x_{ij} - \bar{x}_{.}$). While for a variable at level two z_j, the transformed variable will be equal to ($z_j - \bar{\mathrm{z}}$).

Including a grand mean-centred variable in a regression produces slope estimates (coefficients) equivalent to using the raw scores. The intercept value is the only difference in these forms of centring (Enders, 2013). The intercept of the grand mean-centred variable corresponds to the average outcome when the explanatory variables are equal to the mean value rather than zero in a non-centred variable. Therefore, grand mean centring is useful when the interest is in the value of the intercept, as it provides a reasonable interpretation. Furthermore, centring around the grand mean enhances the models' computational demand, especially in complex multi-level regression models.

In multi-level analysis, the estimated coefficient of the grand mean centred level one explanatory variable is a combination of two components of variation: the first is the within-areas effect, which is the effect on the outcome from the variation between individuals within areas. The second is the between-area effect, which is the effect on the outcome from the variation between areas. For the variable x_{ij}, this corresponds to the mean of x_{ij} within areas ($\bar{x}_j$) minus the mean of x_{ij} for the whole population (the grand mean $\bar{x}_.$) or ($\bar{x}_j - \bar{x}_.$) (Enders, 2013). Therefore, under grand mean centring, the estimated coefficients for the level one variables are potentially influenced by both components of variations (Enders and Tofighi, 2007; Enders, 2013; Bell, Fairbrother and Jones, 2019). The higher-level variables have only one source of variation (the between-area variation). Grand mean centring is appropriate when the research interest is the association between higher-level variables and the outcome.

6.2.9.2 Cluster mean centring

Since using grand mean-centred variables in a multi-level regression will include the between and within clusters components of variation, when the research focus is on lower-level variables or cross-level interaction, some scholars suggest using cluster mean centring (Enders and Tofighi, 2007; Hamaker and Grasman, 2015; Newsom, 2019). Cluster mean centring is achieved by subtracting the clusters' means from the individual scores of the variables at level one. Hence, the variable

x_{ij} is transformed into $(x_{ij} - \bar{x}_j)$. Applying cluster mean centring in a multi-level model will therefore remove the between-clusters component of variability.

However, cluster mean centring requires a specific hypothesis or a theoretical justification that an individual's relative position in the cluster matters (Hox, Moerbeek and van de Schoot, 2010c). This is referred to as "the frog pond effect" in educational research. The idea is that a frog in a pond with smaller frogs experiences different effects than a frog in a pond with bigger frogs (Davis, 1966). For example, poverty at the individual level could have a different impact on health if the person lives in an area with high average poverty compared to living in an area with low average poverty. A further justification required for cluster mean centring is when the effect of the 'within cluster component' is found to be different from the effect of the 'between component' of variation. This can be tested by adding the cluster's means into the regression equation (Hofmann and Gavin, 1998; Raudenbush and Bryk, 2002; Bell, Fairbrother and Jones, 2019).

6.2.9.3 Centring approach adopted in the analysis of this thesis

According to the centring recommendations, grand mean centring is appropriate for research questions 1-6 in this thesis. For the questions related to the cross-level interaction, cluster means centring is advised if strong theoretical reasons support it. In this research’s cross-level interaction analysis, the interest is in three lower-level variables: age, sex, and socioeconomic status (measured by household assets). In the case of age and sex, there is no strong theory that would suggest that the relative position of the individual within areas in relation to these characteristics could influence health.

The socio-economic characteristics (household assets), and according to the 'relative income hypothesis', could be theoretically related to health through social comparison (Kawachi, Subramanian and Almeida-Filho, 2002). Hence, separating the within and the between components of variation might be justified for the household assets variable. However, this was tested by adding the cluster mean of the household assets variable and revealed no significant difference between the two components of variation. This indicated that cluster means centring was not required for the cross-level interaction analysis in this research, and grand mean centring was appropriate and more parsimonious (Bell, Fairbrother and Jones, 2019).

In conclusion, all the lower and higher-level variables were centred around the grand mean, including the categorical variables coded as dummy variables (0,1).

6.2.10 Models and presentation of the results

I conducted several logistic multi-level models to answer the research questions of this thesis. The multi-level models incrementally increased in complexity in the two analyses based on the recommendations of Snijders & Bosker (2012). This section will describe the modelling strategy of the two analyses and the measures reported in the models to answer the research questions.

6.2.10.1 Study one models and measures

The main objective of study one was to assess the general contextual effect and the association between the area-level characteristics and the risk of chronic illness. This study answers research questions 1-6. The following models were conducted:

Model 1: the **null** model, showing the variance in chronic illness between enumeration areas without accounting for the characteristics at the two levels. This model will be compared with all the other models in the analysis.

Model 2: including only the area-level political characteristics, without adjustment for individual-level characteristics. This model assessed the unadjusted effect of the indicators of the political environment without accounting for the green space features of the enumeration areas.

Model 3: including the area-level political and green space characteristics without adjustment for individual-level characteristics. This model assessed the unadjusted impact of all contextual variables used in this study.

Model 4: the **baseline** model includes individual-level characteristics without the area-level characteristics. This model assesses the impact of the individual-level control variables without accounting for the contextual variables.

Model 5: including the area-level political characteristics while adjusting for individual-level characteristics. This model assesses the effect of the political indicators adjusted for the individual-level characteristics without accounting for the green space features of the enumeration areas. Compared to model 2, it assessed the political indicators after adjusting for the individual-level characteristics.

Model 6: the **final** model adjusted for all characteristics at the two levels. Compared to model 3, it assessed the addition of all area-level characteristics after adjusting for the variables at the individual level. Compared to model 5, it assessed the impact of green space after accounting for the individual and the political characteristics.

The following measures are presented in the model results for study one:

- The population average odds ratios and their 95% confidence intervals of the explanatory variables. These were approximated from the multi-level models. Along with the significance presented by a (*) symbol when the p-value was less than 0.05 and a (**) when the p-value was less than 0.01. The confidence intervals and the p-value obtained from the models were based on the Wald Z- statistic. The significance shows whether the explanatory variable was significantly associated with the probability of chronic illness.

- The random effects are reported by the variance (rescaled variance in models with level one variables) and standard deviation.

- The general contextual effect is reported by the interclass correlation coefficient ICC and the median odds ratio (MOR).

- The adjusted total variance explained by the fixed effects (marginal R^2_{dicho}), and the total conditional variance explained by both the fixed and the random effects (conditional R^2_{dicho}).

- The model fit statistics are reported by the deviance.

6.2.10.2 Study two models and measures

The main objective of study two was to assess the interaction between contextual and individual-level characteristics (age, sex, household assets). This study answers research questions 7-9.

The following models were conducted:

Model 1: Extends model 5 in the first analysis with random slopes for age, sex and household assets. This model assesses the extent to which the association between these individual-level variables and the risk of chronic illness differ across enumeration areas without accounting for features of green space in the enumeration areas.

Model 2: Extends model 1, with cross-level interaction terms between age, sex, and household assets variables and the political area-level variables. This model will assess whether the individual-level and the political area-level variables interact in their association with the risk of chronic illness and explain the random slopes without accounting for green space features of the enumeration areas

Model 3: Extends model 2 by adding the green space variables and the cross-level interaction terms between age, sex, and household assets variables and all the area-level variables (green space, refugee camps and political land classification). This model assesses whether these individual-level variables interact with all the area-level variables in their association with the risk of chronic illness.

The following measures were presented in the model's results:

- Log odds and their standard errors. Along with the significance presented by a (*) symbol when the p-value was less than 0.05 and a (**) when the p-value was less than 0.01. The significance shows whether the explanatory variable was significantly associated with the probability of chronic illness.

- The variance and standard deviation report the random effects (intercepts and slopes).

- The deviance reports the model fit statistics.

- The significant interactions will be interpreted by plotting the predicted probability of chronic illness by the variables involved in the interactions.

Chapter seven: Results

In this chapter, I present empirical findings relating to the research questions set out in chapter six, using the multi-level methods as described. The chapter consists of two sections: the first will describe the final sample analysed and the variables included in the models. The second part of the chapter presents the results from the two multi-level logistic regression analyses that answer the research questions. As a reminder, study one investigates the general area effect or the variation in chronic illness attributed to the enumeration areas and the association between the risk of chronic illness with politically created area disadvantage (refugee camps and 'Area C') and the proportion of green space in the enumeration areas (mixed trees, crop trees and open space). Study two investigates the cross-level interaction between the area-level variables with age, sex, and socioeconomic status in their relationship with chronic illness.

7.1 Descriptive statistics

This section will present the summary statistics for the variables included in the models, starting with those at the area level, then at the individual level, and finally, the outcome variable of chronic illness.

7.1.1 Area-level variables

Administrative/ political variables: Locality and political land classification describe the area context of the twin cities in terms of the administrative or political status, which also reflect the composition of these contexts. The locality has three categories: Ramallah, Albireh, and the refugee camps. The political land classification was a binary variable where one indicated 'Area C' and zero indicated area A or B. Table 7-1 presents the numbers and percentages of individuals in each category of these variables.

Table 7-1: Description of locality and political classification

Item	*Population count*	*%*	*Chronic illness N (%)*
Locality			
Ramallah	23317	43	2005 (8.6)
Albireh	27701	50	2477 (9.0)
Refugee camps	3675	7	557 (15.2)
Political class			
A & B	47577	87	4472 (9.4)
C	7116	13	567 (8.0)

Green spaces: Three green space variables were modelled as continuous: the proportion of mixed trees in the enumeration areas, the proportion of open space in the enumeration areas and the proportion of crop trees in the enumeration areas.

Table 7-2 presents a description of these variables.

Table 7-2: Proportion of green space within enumeration areas

Category	*Median (proportion of land cover)*	*Interquartile Range*
Open space	20.1	20
Crop trees	0.15	5.3
Mixed trees	6.8	8.5

7.1.2 Individual-level variables

I used thirteen individual-level variables from the 2017 census, including the outcome variable, chronic illness, described in Table 7-3. I used logarithmically transformed variables for age and years of residence in the multi-level regression models because these variables had a highly negatively skewed distribution and diagnostic plots of model simulated residuals revealed non-random patterns, which violate the linear regression assumptions (Benoit, 2011; Fox and Weisberg, 2019). Transformation enhanced the models' fit, and the residuals became closer to the standard normal distribution.

In general, all the variables were as expected. Despite the maximum age of a few individuals reaching 99 years old, it was a young population, which probably explains why chronic illness levels were quite low overall. Half of the population of the twin cities of Ramallah and Albireh originated from the refugee population. It was slightly higher than the national indicators (41%) and likely because of higher internal migration of refugees to the twin cities from other parts of the oPt, higher birth rate and higher external migration of non-refugees (Kitamura *et al.*, 2018; PCBS, 2019b).

Table 7-3: Description of the individual-level variables of the total sample and the presence of chronic illness

Categorical Variables	Coding	Count	%	Chronic illness N (%)
Chronic illness	Yes	5037	9.2	-
	No	49654	90.8	-
Sex	Female	27581	50.4	2478 (9.1)
	Male	27112	49.6	2561 (9.3)
Refugee status	Refugee	27365	50	3031 (11)
	Not refugee	27328	50	2008 (7.3)
Health insurance	Yes	44531	81.4	4443 (10)
	No	10162	18.6	596 (5.8)
Participation in the labor force	Employed	26141	47.8	1725 (6.6)
	Unemployed	1980	3.6	100 (5)
	Studying	11293	20.6	130 (1.1)
	Housework	10315	18.9	1119 (10.8)
	Other	4964	9.1	1965 (39.6)
Education	Higher education	23658	43.3	1538 (6.5)
	High school 11-12 years	11314	20.7	757 (6.7)
	preparatory 7-10 years	12321	22.5	960 (7.8)
	Primary 1-6 years	4665	8.5	771 (16.5)
	No education	2735	5	1013 (37)
Marital status	Married	31876	58.3	3680 (11.5)
	Single	20344	37.2	526 (2.6)
	Other	2409	4.5	833 (33.7)
Residential type	Apartment	46357	84.8	3924 (8.5)
	House or Villa	8336	15.2	1115 (0.13)
Tenure	Own	40627	74.3	3732 (9.2)
	Rent	14066	25.7	1307 (9.3)
Private car ownership (count)	One or more cars	35757	65.4	2581 (7.2)
	No car	18936	34.6	2458 (13)
Continuous variables	**Mean**	**Range**		
Age (years)	36.1	14-98		
Years of residence	24.8	1-98		
Household assets scale	0.04	-1.73-1.68		

7.2 Multi-level regression results

7.2.1 Study one

Study one answers research questions 1-6, as presented in chapter six. It explored the variation in chronic illness attributed to the enumeration areas and the association between area characteristics with the risk of chronic illness. The characteristics of enumeration areas were the following:

- The locality that the enumeration areas belong to (Ramallah, Albireh and Refugee camps).
- The political land classification of the enumeration area ('Area A and B' and 'Area C').
- The proportion of green space in the enumeration areas (mixed trees, crop trees and open space).

In chapter six, I stated that I would run six models to answer the research questions 1-6 with each model and compare them, providing specific information about area effects on the probability of chronic illness. Table 7-4 reports the output from these six models.

Table 7-4: Population average odds ratios and 95% confidence intervals from multi-level models for the analysis of the association between enumeration area characteristics and the risk of chronic illness

Model	1 Null	2	3	4 Baseline	5	6 Final
Area characteristics						
Albireh vs Ramallah	-	1.19[16] (0.99-1.44)	1.12 (0.93-1.35)	-	1.13 (0.91-1.40)	1.03 (0.84-1.27)
Refugee camps vs Ramallah	-	**2.14** (1.41-3.27)**	1.47 (0.94-2.32)	-	**1.91** (1.17-3.09)**	1.38 (0.83-2.29)
Political class C vs A&B	-	0.84 (0.64-1.11)	0.87 (0.65-1.16)	-	0.89 (0.65-1.21)	0.77(0.56-1.06)
Percent mixed trees	-	-	**0.97** (0.96-0.99)**	-	-	**0.96** (0.95-0.97)**
Percent crop trees	-	-	1.01 (0.99-1.02)	-	-	1.01 (0.99-1.02)
Percent of open space	-	-	**0.99** (0.98-0.99)**	-	-	0.99 (0.99-1.01)
Individual characteristics						
<u>Log(age)</u>	-	-	-	**25.1** (21.5-29.1)**	**25.39** (21.8-29.5)**	**26.12** (22.4-30.4)**
<u>Female vs male</u>	-	-	-	**0.81** (0.74-0.89)**	**0.81** (0.74-0.89)**	**0.81** (0.74-0.89)**
3rd level school vs high education	-	-	-	**1.27** (1.15-1.40)**	**1.27** (1.15-1.40)**	**1.27** (1.15-1.40)**
2nd level school vs high education	-	-	-	**1.59** (1.43-1.75)**	**1.58** (1.43-1.75)**	**1.59** (1.43-1.75)**
1st level school vs high education	-	-	-	**1.98** (1.76-2.22)**	**1.98** (1.76-2.22)**	**1.98** (1.76-2.22)**
No education vs high education	-	-	-	**2.05** (1.81-2.32)**	**2.05** (1.81-2.32)**	**2.05** (1.81-2.32)**
Unemployed vs employed	-	-	-	**1.34** (1.08-1.66)**	**1.34** (1.08-1.66)**	**1.34** (1.08-1.66)**
Studying vs employed	-	-	-	**1.91** (1.55-2.37)**	**1.92** (1.55-2.38)**	**1.93** (1.56-2.39)**
Housework vs employed	-	-	-	**1.33** (1.19-1.49)**	**1.33** (1.19-1.49)**	**1.33** (1.19-1.49)**
Other vs employed	-	-	-	**1.83** (1.66-2.02)**	**1.83** (1.66-2.02)**	**1.84** (1.67-2.03)**
Married vs single	-	-	-	0.93 (0.82-1.05)	0.93 (0.82-1.05)	0.92 (0.82-1.04)
Widow-Divorce vs single	-	-	-	**1.19* (1.01-1.39)**	**1.19* (1.01-1.39)**	**1.19* (1.01-1.39)**
<u>Refugees vs non-refugees</u>	-	-	-	**1.15** (1.06-1.23)**	**1.15** (1.06-1.23)**	**1.15** (1.06-1.23)**
<u>Health insured vs non-insured</u>	-	-	-	**1.61** (1.45-1.80)**	**1.61** (1.45-1.80)**	**1.62** (1.45-1.80)**
<u>Log (years of residence)</u>	-	-	-	1.02 (0.97-1.06)	1.01 (0.97-1.06)	1.02 (0.97-1.06)
<u>Private car vs no private</u>	-	-	-	**0.88** (0.82-0.96)**	**0.89** (0.82-0.96)**	**0.89** (0.82-0.96)**
<u>Household assets</u>	-	-	-	**0.93** (0.88-0.99)**	**0.93** (0.88-0.99)**	**0.93** (0.88-0.99)**
Enumeration Area effect						
Variance	0.51	0.473	0.423	0.359	0.344	0.293
ICC	13.4%	12.4%	11.4%	9.4%	9.0%	7.7%
MOR	1.98	1.93	1.86	1.77	1.75	1.68
$\boldsymbol{R^2_{dicho}}$ *Marginal*	-	1.2%	2.5%	38.3%	38.9%	40.2%
$\boldsymbol{R^2_{dicho}}$ *Conditional*	13.4%	13.6%	13.6%	47.7%	48%	48%
Deviance	2484	32470	32448	23604	23596	23564

[16] OR- population average odds ratio; CI-confidence interval (upper-lower); ** P-value<0.01; *P-value<0.05 based on the Wald test of significance, indicates the explanatory variable is significantly associated with the risk of chronic illness (in bold).

Model 1 (the null model) showed that, without accounting for any characteristics, 13.4% of the variance in the propensity for chronic illness was attributed to the clustering effect of the enumeration area level. The Median Odds Ratio (MOR) for the enumeration area level indicates that if an individual moved from an enumeration area with a lower risk of chronic illness to an enumeration area with a higher risk, their risk of chronic illness could increase 1.98 times.

Model 2 added area-level political characteristics to the null model. These variables explained 1.2% of the total variance in the propensity of chronic disease. The association between chronic illness and residence in refugee camps was statistically significant (though this model does not account for the characteristics of individuals). Adding the area-level variables reduced the variance attributed to the enumeration area-level to 12.4%, and the MOR decreased to 1.93.

Model 3 added the green space variables to model 2, explaining 2.5% of the total variance in chronic illness. The association between refugee camps and chronic illness risk was considerably attenuated and no longer statistically significant. Both mixed trees and open space have a significant negative association with chronic illness risk, but again remember that this was without accounting for individual-level variables.

In models 4, 5 and 6, individual-level characteristics were included. Adding residential type and tenure did not improve the model fit (tested via a likelihood ratio test and the deviance), and those were discarded. In Model 4 (baseline), the individual-level variables were added to the null model, explaining 38.3% of the total variance and 29.6% of the variation in chronic illness propensity between enumeration areas. Estimates of the association between the probability of chronic illness and the individual-level variables were all statistically significant, except for years of residence and being married.

In model 5, the area-level political variables were added to model 4. Having now adjusted for the individual-level characteristics, these area-level characteristics explained 7% of the total variance in the probability of chronic illness and 4% of the variance at the enumeration areas level. Compared to model 2, the association between residence in refugee camps and chronic illness was attenuated but persisted (OR 1.91 CI [1.17-3.09]). There was no difference in odds of chronic illness for those residents in Albireh, compared with Ramallah, or for residents in the political land classifications C, relative to A and B (combined).

The final model (Model 6) included all variables at the individual and area levels. This model explained 40.2% of the total variance and 42.5% of the variance at the enumeration area level in the probability of chronic disease. In addition to the clustering at the enumeration areas, all the explanatory variables explained 48% of the variance overall. Green space variables added in the final model explained 1.3% of the variance of chronic illness between individuals and 15% of the variance across enumeration areas, accounting for individual and political characteristics. All the area-level characteristics included in the final model (locality, political land classification and urban green space) explained 18.4% of the variation in the risk of chronic illness at the enumeration area level, accounting for the individual characteristics.

Of the three green space variables, only the proportion of mixed trees in enumeration areas was significantly associated with chronic illness, with a 4% reduction in odds for a 1% increase in the proportion of mixed trees (OR 0.96 CI [0.95-0.97]). There was no evidence that the proportion of open space or crop trees in the enumeration areas was associated with chronic illness.

Figure 7-1 shows the predicted probability of chronic illness taken from the final model against the range of proportion of mixed trees in the enumeration areas (0.1% to 40.7%). This prediction accounts for all the other variables and shows a trend suggesting that the predicted probability of chronic disease decreased as the proportion of mixed trees within enumeration areas increased.

Figure 7-1 also shows the interquartile range. This helps interpret the relationship. It indicates that living in the 3rd quartile of the range of values for the proportion of mixed trees was associated with a 2.8% probability of chronic illness and that this was lower than the 4% probability of chronic illness associated with living in the 1st quartile of the range, all else being equal.

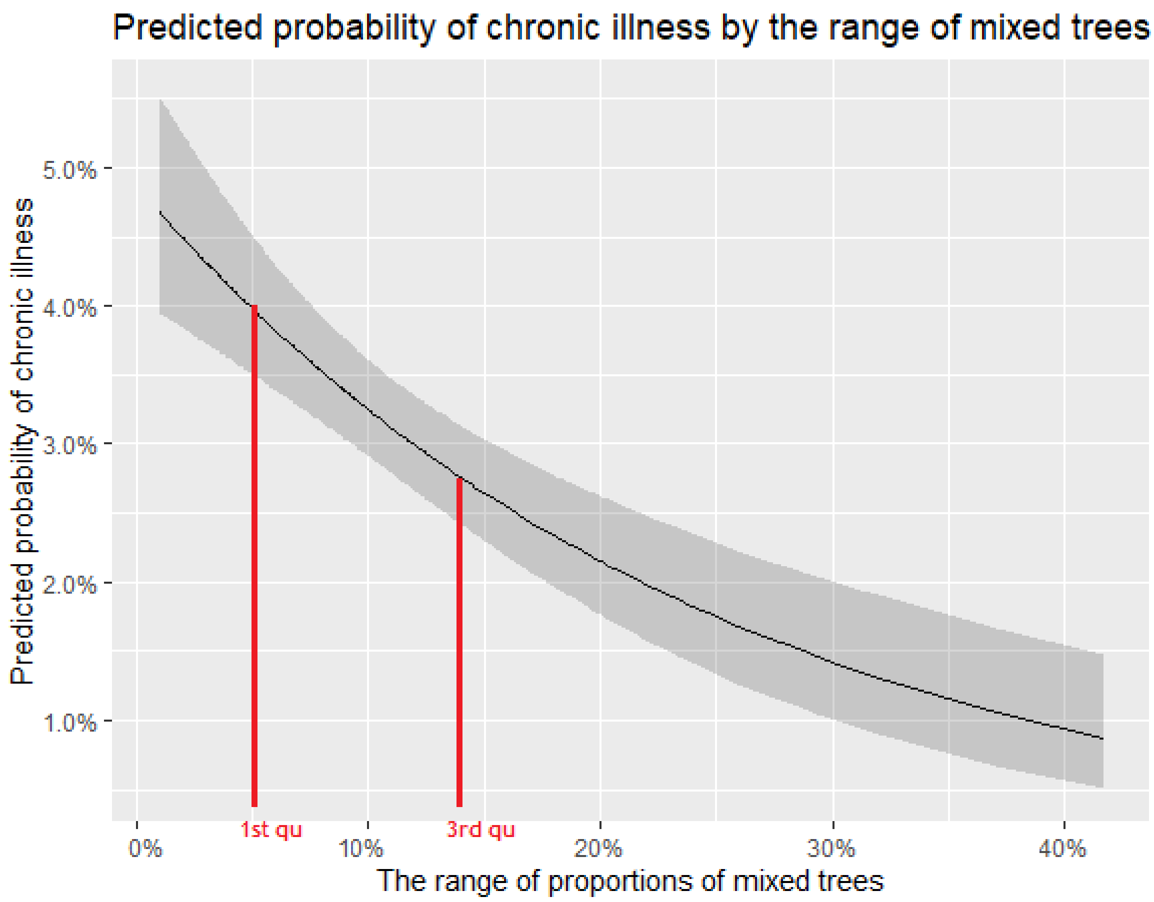

Figure 7-1: The predicted probability of chronic illness by the range of the proportion of mixed trees in the enumeration areas of residence

None of the political variables or the other two green space categories (open space and crop trees) was associated with chronic illness risk in Model 6. The association between living in refugee camps and chronic illness was again attenuated and non-significant when adding green space variables. Compared to the baseline model (only with the individual level control variables), the final model shows that adding the area-level characteristics explained 18.4% of the variability at the area level. Accounting for the individual and the area-level characteristics in the final model, the remaining variance in chronic illness attributable to the variation between enumeration areas was 7.7%. In odds ratio terms, the worst-performing enumeration areas have 1.68 times higher odds of chronic illness than the best-performing enumeration areas, which remained unexplained by the model's variables. It is worth mentioning that adding the area-level characteristics separately in the models did not provide further information to the models presented earlier and odds ratios had approximately similar magnitude.

7.2.2 Study two

In study one, I investigated the main effects of the individual and area-level variables on the probability of chronic illness. The second analysis presented here addressed research questions 6-9. Specifically, study two assessed the cross-level interaction between personal characteristics (age, sex, and household assets) and area-level features (refugee camps, political classification, and the proportion of mixed trees) in their association with the risk of chronic illness.

Initially, I intended to investigate the interaction between the individual characteristics and all green space variables. However, including the proportion of open space and crop trees variables in the models resulted in singular fits and mis-convergence. The singularity warning suggested that the models were overfitted and might have poor power. I further attempted to include only cross-level interaction terms with these variables, but this also resulted in a singular fit. Both the proportion of crop trees and open space had a very small effect size, and it might be that the data are not sufficient for these models. Reducing the complexity of the models was required. Thus, I dropped the interaction terms with the proportion of crop trees and open space (Bates, Maechler, *et al.*, 2015). Table 7-5 presents the log odds and standard error in the three models, as explained in chapter six.

Table 7-5: Models with cross-level interactions of age, sex and socioeconomic status with area variables in their association with the risk of chronic illness

	Random slopes Model 1: only with political variables	**Interactions model 2: only with political variables**	**Final model 3: all area-level variables**
Fixed effects	Log-odds(std.error)	Log-odds(std.error)	Log-odds(std.error)
Intercept	-3.40 (0.05) **	-3.39 (0.05)**	-3.40 (0.05) **
Area characteristics			
Ramallah	*Reference*	*Reference*	*Reference*
Albireh	0.19 (0.10)	0.20 (0.10)	0.10 (0.10)
Refugee_camps	**0.55 (0.22) ***	**0.47 (0.24) ***	0.18 (0.25)
Political class A&B	*Reference*	*Reference*	*Reference*
Political class C	-0.08 (0.15)	-0.09 (0.14)	-0.18 (0.16)
% Mixed trees			**-0.03 (0.01) ***
% Crop trees			$-5e^{-3}$ $(5e^{-3})$
% Open space			$-3e^{-3}$ $(3e^{-3})$
Individual characteristics			
Log(age)	**3.31 (0.11) ****	**3.30 (0.11) ****	**3.31 (0.11) ****
Sex: female	**-0.19 (0.05) ****	**-0.21 (0.05) ****	**-0.20 (0.05) ****
higher education	*Reference*	*Reference*	*Reference*
3rd level school	0.27 (0.05) **	0.27 (0.05) **	0.27 (0.05) **
2nd level school	0.50 (0.05) **	0.51 (0.05) **	0.51 (0.05) **
1st level school	0.75 (0.06) **	0.75 (0.06) **	0.75 (0.06) **
No education	0.80 (0.07) **	0.81 (0.07) **	0.80 (0.07) **
Employed	*Reference*	*Reference*	*Reference*
Unemployed	0.32 (0.12) **	0.32 (0.12) **	0.32 (0.12) **
Studying	0.59 (0.12) **	0.59 (0.12) **	0.59 (0.12) **
Housework	0.28 (0.06) **	0.28 (0.06) **	0.28 (0.06) **
other	0.65 (0.05) **	0.66 (0.05) **	0.66 (0.05) **
Single	*Reference*	*Reference*	*Reference*
Married	-0.07 (0.07)	-0.07 (0.07)	-0.08 (0.07)
Widow-Divorce	0.20 (0.08) *	0.19 (0.08) *	0.19 (0.08) *
Refugee status: refugees	0.15 (0.04) **	0.15 (0.04) **	0.15 (0.04) **
Health insurance: insured	0.51 (0.06) **	0.51 (0.06) **	0.51 (0.06) **
Log (years of residence)	0.02 (0.02)	0.02 (0.02)	0.02 (0.02)
Private car: yes	-0.12 (0.04) **	-0.12 (0.04) **	-0.12 (0.04) **
Household assets scale	**-0.11 (0.03) ****	**-0.11 (0.04) ****	**-0.10 (0.04) ****
Cross-level interactions			
Refugee camp * Log(age)		0.41 (0.34)	-0.27 (0.35)
Refugee camp * female		**0.28 (0.13) ***	0.28 (0.14) *
Refugee camp * H assets		-0.09 (0.13)	-0.08 (0.13)
Area C * Log(age)		-0.28 (0.24)	0.41 (0.24)
Area C * Female		-0.05 (0.11)	-0.06 (0.12)
Area C * H assets scale		-0.12 (0.09)	-0.12 (0.10)
Mixed trees * Log(age)			-0.02 (0.01)
Mixed trees * Female			$-8e^{-4}$ $(6e^{-3})$
Mixed trees * H assets			$1e^{-3}$ $(5e^{-3})$
Random effects	variance (s.d)	variance (s.d)	variance (s.d)
Random intercept	0.34 (0.58)	0.34 (0.58)	0.30 (0.55)
Random slope: log(age)	0.82 (0.90)	0.78 (0.88)	0.75 (0.87)
Random slope: female	0.04 (0.20)	0.03 (0.16)	0.03 (0.16)
Random slope: H assets	0.06 (0.24)	0.06 (0.24)	0.06 (0.24)
Deviance	23458	23446	23415

P-values ** <0.01, *<0.05

Model 1 is the random slopes model, which allows the associations between the three individual-level variables (age, sex, and socioeconomic status) and the probability of chronic illness to be random across enumeration areas (i.e., each enumeration area had its own regression line). Allowing for random slopes for these variables significantly improved the model fit compared to the model without random slopes with the same fixed effects (model 5 from study one). Model 1 shows that variances in slopes between enumeration areas were 0.82 for log (age), 0.04 for sex and 0.06 for household assets.

For sex, the value of the coefficient for the difference between males and females (in log-odds) was -0.19, which was the average across enumeration areas. Given that the slope standard deviation was 0.2, the coefficient for sex ranged from 0.21 in enumeration areas in the top 2.5% of the area-dependent effects (two standard deviations above the average) to -0.59 in enumeration areas in the bottom 2.5% of the area-dependent effects. Thus, there are not only sizable differences in the magnitude of the association between sex and risk of chronic illness across enumeration areas but also differences in the direction of the association. In some enumeration areas, females have a lower average risk of chronic illness compared to males, but in other enumeration areas, females have a higher average risk of chronic illness. The association between household assets also presented similar patterns ranging from 0.38 to -0.6 from the average slope (-0.11). The association between log(age) and the probability of chronic illness did not change in direction; however, the difference in the magnitude of the association was relatively high, around the average of 3.31, ranging from 1.5 to 5.12 across enumeration areas.

Models 2 and 3 included cross-level interaction terms. Model 2 had only the political variables and their interaction with personal variables, while model 3 added all the green space variables and the interaction term between the proportion of mixed trees and personal characteristics. In model 2, only the cross-level interaction between refugee camps and sex (female) was statistically significant, with log-odds equal to 0.28 and a standard error of 0.13. The random slope variance for sex in model 2 compared to model 1 was reduced by 35%, indicating that the interaction terms explained around one-third of the variation in the association between sex and the probability of chronic illness across enumeration areas.

In model 3, none of the interactions between the proportion of mixed trees in the enumeration areas and the individual-level variables were significant, with small effect sizes. This indicated no evidence of an interaction effect between the proportion of mixed trees and age, sex, and household assets in their association with the probability of chronic illness. Adding green space variables in model 3 explained the positive association between living in refugee camps and the probability of chronic illness, but the statistically significant interaction between sex and refugee camp persisted. Neither the estimate of the interaction between sex and refugee camps nor the random coefficient variance of sex changed in model 3 compared to model 2, suggesting that green spaces do not alter the interaction between sex and refugee camps.

In model 3, the interpretation of the main effect of sex now reflects females' log-odds compared to males living outside the refugee camps (OR 0.81 CI (0.73-0.89)). The main effect of refugee camps (which was not statistically significant) reflects the log odds of living in refugee camps for males (OR 1.07 CI (0.66-1.73)). The odds ratio of the cross-level interaction was 1.34 (1.04-1.74), which reflects the odds ratio difference between the effect of being a female on chronic illness for those living inside refugee camps compared to the effects of being a female for those living outside refugee camps. The significant difference suggests that females and males respond differently to this different context, living outside versus living inside refugee camps. Females have a statistically significant lower risk of chronic illness compared to males (accounting for all the other variables included in the models) but not in the context of refugee camps.

The estimates of the interaction terms are complex and challenging to interpret without considering the values of the intercept and other variables in the model. The best way to understand the interaction term was to plot the predictive values for sex and refugee camps while considering all other variables in the model. Figure 7-2 does this and shows the predicted probability of chronic illness obtained from the final model, calculated and plotted for males and females living inside and outside refugee camps. It shows that the positive relationship between living in a refugee camp and the risk of chronic illness was more pronounced for females compared to males. Females living outside refugee camps have significantly lower odds of chronic illness than males (statistically tested, as the CI didn't overlap with the mean). But for those living *inside* refugee camps, females have a higher probability of chronic illness than males, though this was not a statistically significant difference. Assuming we have a hundred females, the model estimates four out of the hundred females are predicted to develop a chronic illness if they live in a refugee camp, whereas three are expected to develop a chronic disease if they live outside the refugee camps. In contrast, males had a relatively similar risk of chronic illness regardless of living outside or inside refugee camps.

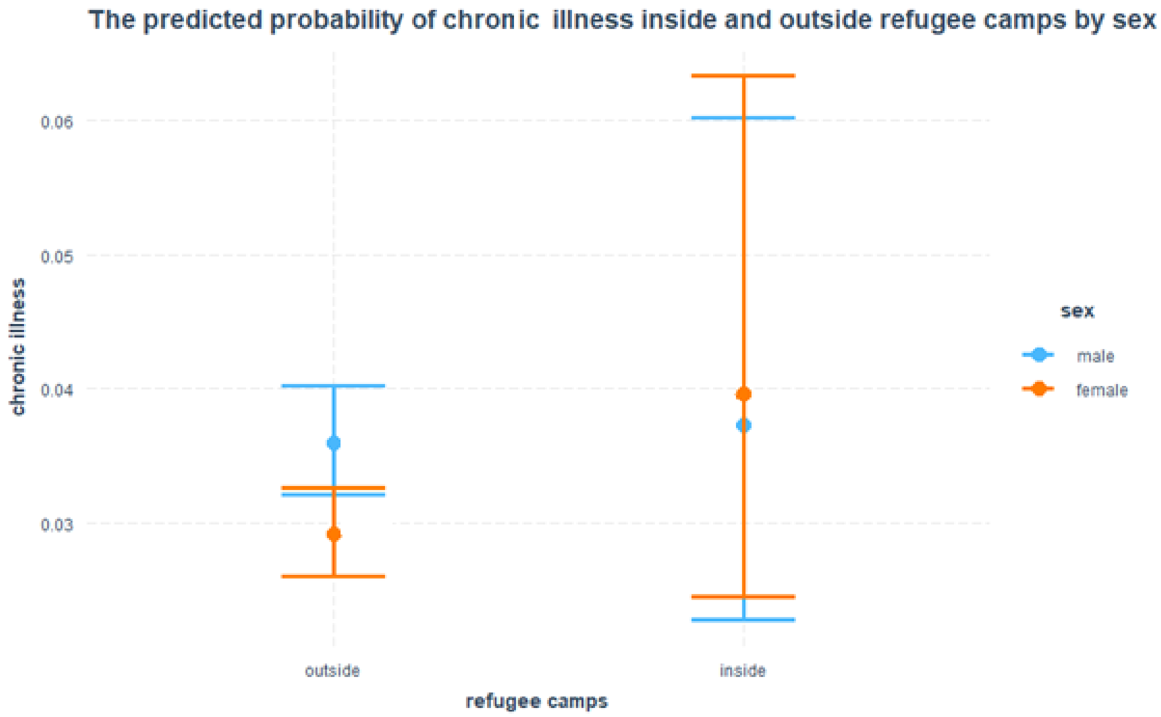

Figure 7-2: The predicted probability of chronic illness for females and males living inside and outside refugee camps

7.3 Conclusion

In this chapter, I presented the results from the analysis of the two studies. The main messages were that residential areas are relevant to chronic illness risk in the twin cities of Ramallah and Albireh. Second, most of the individual-level variables were associated with chronic illness. The absence of an association between tenure and chronic illness was unexpected and might be related to higher tenure security in the twin cities and the high number of housing mortgage loans (Harker, 2017; Morris, 2018). Third, the context of refugee camps was associated with chronic illness, which was explained by accounting for green space. Fourth, from the green space variables, only the proportion of mixed trees was associated with chronic illness. Finally, only one interaction effect was significant between sex and refugee camps. These findings about the area-level variables will be discussed in more detail in the following chapter and connected to other results in the literature.

Chapter Eight: Discussion

In this thesis, I investigated aspects of the urban environment of the twin cities of Ramallah and Albireh in oPt and their association with health. The main objectives were:

- To assess the influence of the context of residential areas on health.
- To investigate the associations between health and politically created disadvantage (refugee camps and political land classification) and urban green space.
- To investigate the interactions between the features of residential areas and individual-level demographic and socioeconomic characteristics in their associations with health.

The thesis had two key phases. The first phase included identifying, acquiring, preparing, and processing geographic and census data for the twin cities of Ramallah and Albireh. The geographical data included two aspects of the urban environment of the twin cities: (1) the politically created disadvantage and (2) urban green space. The indicators of the politically created disadvantage were the context of refugee camps and the context of the area politically classified as 'Area C' (under full Israeli occupation), which are disadvantaged at multiple levels. I created a land cover surface dataset that described the urban green space and separated it into three key green space categories: open space, crop trees and mixed trees. Using this urban green space layer, I described the proportion of these categories in each enumeration area.

In the second phase, I applied two-level logistic regression for two studies to model the probability of chronic illness with individual and household-level variables obtained from the 2017 census and the area-level variables. Study one aimed to explore the general 'area-effect' on chronic illness and the association between the risk of chronic illness and the area-level variables (refugee camps, political land classification and urban green space), accounting for several individual-level characteristics. Study two aimed to explore the interaction between the area-level features and personal factors, namely age, sex, and household socioeconomic status, in their association with the risk of chronic illness.

This chapter will summarise the results from studies one and two and discuss the findings with reference to previous studies. It will consider the strengths and limitations of this research and its methods. Finally, it will highlight the implications of the findings and recommendations for future policies and research.

8.1 Study one: The analysis of the general 'area effect' and the association between area-level characteristics and the risk of chronic illness

This section will discuss the findings concerning each research question addressed by study one and in the context of other international and regional literature. I will include the key findings at the end of each research question.

8.1.1 Research question 1: how important is the context of the residential areas defined by the boundaries of the enumeration areas for the risk of chronic illness in the twin cities of Ramallah and Albireh?

In this thesis, I defined residential areas using the enumeration area boundaries of the 2017 census. Although using fixed and predetermined boundaries was one of the limitations of this research (discussed later in this chapter), the findings showed that they are relevant to health.

I found that 13.4% of the individual differences in chronic illness in the twin cities of Ramallah and Albireh were at the enumeration area level. Thus, there was evidence that the area effects captured by enumeration area boundaries were relevant to individual differences in chronic illness. The amount of variability of chronic illness that was attributed to the enumeration areas in this research was relatively high compared to other studies that estimated the area effects on different chronic health outcomes (Merlo *et al.*, 2006, 2013; Mowafi *et al.*, 2012; Mezuk *et al.*, 2013; Müller *et al.*, 2018). For example, Mezuk et al.(2013) investigated the 'area effect' on the risk of type two diabetes in Malmo, Sweden. They found that 3.5% of the variation in this health condition was attributed to residential areas without adjusting for individual differences. Similarly, a study in Cairo, Egypt, found that 2.5% of the variation in BMI was attributed to residential areas (Mowafi *et al.*, 2012). These figures were about four times higher in this research.

The magnitude of the contextual effect in this research was also relatively high compared to the aforementioned studies and other studies after adjusting for individual-level differences (compositional factors). 9.4% of the difference in chronic illness in this study remained attributed to enumeration areas, which was a better indicator of the 'true' contextual phenomenon. For example, a study in Toronto, Canada, found that 6% of the variation of chronic conditions was attributed to neighbourhoods, adjusting for age, gender, education and nativity (O'Campo et al., 2015). While a study that investigated all-cause mortality in Andalusia, Spain, found that 3% of the variation was attributed to census tracts, adjusting for gender, residential mobility, and other compositional factors (Merlo, Viciana-Fernández and Ramiro-Fariñas, 2012). The context of enumeration areas used in this research was more relevant to the risk of chronic illness compared to community (locality) boundaries, according to a study by Bates et al.(2017). They investigated chronic illness for females in the oPt accounting for individual characteristics that are quite similar to this research. They found that 4.3% of the risk of chronic illness was attributed to the community context.

Despite these various estimates of the area effects not being directly comparable because of differences in the contexts, population, outcomes, and characteristics included in the models, they provide helpful insight into the relevant role of the context of the enumeration areas used in this thesis in the distribution of chronic illness in the twin cities of Ramallah and Albireh.

All the individual and area-level explanatory variables modelled in this research and the unobserved area-level effects explained 48% of the overall variance in the probability of chronic illness in the twin cities of Ramallah and Albireh. The remaining factors behind the unexplained variance in chronic illness might be related to differences between people that were not accounted for, such as behavioural and familial factors, or contextual factors other than those delineated by residential (enumeration) areas, such as political, economic, social, occupational, environmental and cultural factors at different scales (Voigtländer, Razum and Berger, 2013; Richardson *et al.*, 2017).

Key message: my research found that the context of the residential areas, defined by the boundaries of the enumeration areas, was relevant to the risk of chronic illness in the twin cities. The variance in health attributed to residential areas was almost three/four times higher than in other studies in the Middle East and the Global North.

8.1.2 Research question 2: what is the relationship between living in the context of a refugee camp and the risk of chronic illness?

Like many refugee camps in the developing world, the refugee camps in the oPt started as temporary settings for refugees who fled their lands around 1948 and gradually transformed into durable disadvantaged socio-spatial formations within the urban environments. As detailed in chapters three and four, the environmental conditions in refugee camps are extremely challenging, with many social and physical disorders. Therefore, living in the disadvantaged context of refugee camps was hypothesised to increase the risk of chronic illness, over and above individual-level factors.

As expected, the findings revealed that, for people living in refugee camps, the odds of chronic illness increased by 91% compared to Ramallah residents, over and above their personal characteristics. The findings confirmed previous research in the oPt and worldwide (detailed in chapter three) that the unfavourable environment of protracted refugee camps and the challenges faced by their residents have a toll on their health and well-being (Al-Khatib, Arafat and Musmar, 2005; Crea, Calvo and Loughry, 2014; Qumseya *et al.*, 2014; Harsha *et al.*, 2016; Bates *et al.*, 2017; Jonassen *et al.*, 2018; Vossoughi *et al.*, 2018; Behnke *et al.*, 2020). They also agreed with the international literature about area disadvantage and its links to adverse health outcomes (Bambra, 2016; Chyn and Katz, 2021).

For example, in the oPt, Jonassen et al. (2018) found that living in refugee camps was associated with about 40% higher odds of chronic illness than living outside refugee camps. They adjusted for several demographic and socioeconomic variables like those included in this study, but also for smoking. Smoking is a risk factor for chronic illness, and adjustment for it would shrink the area effect, which might explain why this study's effect size was twice as large. Moreover, I was able to explore the impact of previously living in a refugee camp by comparing the risk for individuals with a refugee background with those without a refugee background. The results indicated that previously living in a refugee camp holds negative consequences later in the life course for those who now reside elsewhere. Adjusting for the refugee background in this research accounted for possible familial, social, and historical shared factors between refugees currently living inside refugee camps and those who left refugee camps and lived elsewhere in the twin cities. Thus, the estimate of the risk associated with living in refugee camps in this research was a better indicator of the contextual social and physical challenges and exposures related to the disadvantaged context of refugee camps.

Few previous studies about the link between refugee camps and health have addressed their social and physical context (Hynie, 2018; Emerson *et al.*, 2021). The findings of this research indicated that the physical features of the urban environment captured by urban green space explained about 50% of the higher risk of chronic illness in refugee camps and rendered the association between refugee camps context and the risk of chronic illness non-significant. It highlighted the beneficial role urban green space (specifically land covered with mixed trees) might play in reducing the risk of chronic illness in such a disadvantaged context.

Green space, specifically trees, is an important component of a healthy and sustainable urban environment. Its role in explaining the negative impact of the refugee camp context on the risk of chronic illness might be due to multiple related pathways or factors. One might be through direct effects such as restoring mental health and reducing stress, which might be an essential pathway in mitigating the stressful environment of the refugee camps (Ward Thompson *et al.*, 2012). However, the association probably reflects a combination of factors that define the overall quality of the refugee camp's physical and social environment. More green space may indicate the presence of multiple aspects of a physical environment that supports health. For example, more green space might imply less air pollution, more spaces and pathways encouraging physical, social, and recreational activities, and more natural biodiversity (Aerts *et al.*, 2020; Dzhambov *et al.*, 2020). These severe problems characterise refugee camps in the oPt (Al-Khatib *et al.*, 2003; Jonassen *et al.*, 2018).

Key message: my research found that living in a refugee camp was associated with adverse health consequences, increasing the odds of chronic illness by 91% compared to those living in Ramallah. The results also suggested that previously living in a refugee camp was negatively associated with the risk of chronic illness throughout the life course. Finally, the physical environmental features captured by green space explained about 50% of the high risk of chronic illness in refugee camps.

8.1.3 Research question 3: what is the relationship between living in the context of areas politically classified as 'Area C' and the risk of chronic illness?

The political land classification was the second marker of area disadvantage in the urban environment of the twin cities of Ramallah and Albireh investigated. The land, politically classified as 'Area C', is under complete Israeli military occupation, controlling the security and administration of this area. Compared with 'Area A' and 'Area B', 'Area C' is disadvantaged at multiple levels, as discussed in chapter four.

Yet, little is known about the role of the context of 'Area C' in the oPt in shaping the health of the residents. This research addressed this gap and hypothesised that living in the political classification 'Area C' was positively associated with an increased risk of chronic disease. However, the results did not support this hypothesis, which was unexpected given the unfavourable living conditions in this area. Unfortunately, there were no directly comparable studies against which to set this finding. To my knowledge, this was the first study to investigate the links between the political land classification in the oPt and health outcomes.

It might be argued that the effects of living in an area politically classified as 'Area C', as a source of power territoriality and fragmentation, on health were not well-captured in the context of the twin cities of Ramallah and Albireh, a centralised urban setting. It might also be related to the proximity of areas classified as 'Area C' to the urban centres of the twin cities, which may mean access to services, amenities and health care was not as dramatically affected by the political classification in this setting as other locations. Finally, areas classified as 'Area A' and 'Area B' could also have other environmental, social, and political problems and detecting a difference in the risk of chronic illness compared to 'Area C' would be difficult. As described in chapter four, the entire oPt faces historical and continued political, societal, and environmental challenges. However, further data and analysis are required to confirm these assumptions. Perhaps the influence of political classification would be better captured in peripheral sites, such as remote villages and rural areas in the West Bank or even in other localities, where this designation impacts more aspects of life. Further research is needed, with a broader geographical scope.

Key message: My research did not detect variation in risk of chronic illness between different politically classified areas across the oPt.

8.1.4 Research questions 4, 5, and 6: what is the relationship between the proportion of mixed trees, crop trees, and open space in the areas of residence and the risk of chronic illness?

The current study builds upon previous literature, mainly in the Global North, that urban green space was associated with better physical and mental health outcomes and mortality (Markevych *et al.*, 2017; Rojas-Rueda *et al.*, 2019). The findings were consistent with previous studies that found that urban green space was inversely associated with the risk of chronic health conditions (Maas *et al.*, 2009; Brown *et al.*, 2016; Massa *et al.*, 2016; Twohig-Bennett and Jones, 2018; Dalton and Jones, 2020). Despite that, it would be difficult to compare with the results of this thesis because of the considerable differences with the Middle Eastern Arab context.

Some recent studies emerging from South America and East Asia also suggested that green space benefits health (Massa *et al.*, 2016; Mukherjee *et al.*, 2017; Hong *et al.*, 2021; Rahimi-ardabili *et al.*, 2021). However, in studies stemming from the Global South, which has the highest burden of diseases, the evidence is still weak, mainly due to the low number and quality of studies (Rigolon *et al.*, 2018; Labib, Lindley and Huck, 2019; Luo *et al.*, 2020; Shuvo *et al.*, 2020). Furthermore, there are vast differences between the contexts within the Global South. Some regions, like the Middle Eastern Arab region, are poorly represented in research, as demonstrated in chapter three. Amid the uneven distribution of evidence, this research was important because it addressed an understudied and unique social, cultural, and climatic context of the Middle Eastern Arab region.

8.1.4.1 The Middle Eastern Arab Context

This was the first research to investigate urban green space and health in the oPt. As demonstrated in the literature search in chapter three, only one population-level study was found that connected green space with health-related outcomes in the Middle Eastern Arab region. This study was conducted in Egypt, where obesity was the outcome measure, and found no association with green space (Mowafi *et* *al.*, 2012). Given that obesity is considered a significant risk factor for chronic illness (Teo *et al.*, 2009) and the similarities with the current study in the culture and context, multi-level methodology and control variables included, this was a surprising result. However, the difference in the measures of green space and health outcomes in both studies might explain the different findings. For example, an essential link between green space and obesity is its role in encouraging physical activity (Lachowycz and Jones, 2011; Luo *et al.*, 2020). However, physical activity might not be as strong as the other pathways between green space and chronic illness in conservative Arab contexts. Outdoor physical activity is not generally common or culturally acceptable especially for females. Other important pathways between green space and health outcomes, such as those related to mental health or harmful environmental exposures, might be more relevant in the Arab context.

Furthermore, unlike this research, Mowafi *et al.* (2012) measured green space using the number and proportion of green spaces (such as gardens and parks) within the residential area rather than the proportion of green land cover. Notably, they did not differentiate between trees and other types of green spaces. They did not include small patches of trees or street trees, which seem to be essential elements in the current research.

8.1.4.2 Not all green spaces were associated with better health

Since most of the previous studies on the relationship between health and green space have not separated different types of greenery, my ability to do so was important, and it answered multiple calls from scholars (Wheeler *et al.*, 2015; Zupancic, Westmacott and Bulthuis, 2015; Markevych *et al.*, 2017; Reid *et al.*, 2017; Labib, Lindley and Huck, 2019).

My research found that not all green space categories were associated with a lower risk of chronic illness. It did not find an association between the proportion of open 'green' space without trees in the residential areas and the risk of chronic illness. It highlights the health benefits of trees as a particularly important form of urban nature as opposed to non-tree vegetation. This supports the recently growing literature (Donovan *et al.*, 2013; Mitchell, 2013; Kardan *et al.*, 2015; Reid *et al.*, 2017; Astell-Burt and Feng, 2020b; Astell-Burt, Navakatikyan and Feng, 2020; Nguyen *et al.*, 2021). For example, a systematic review demonstrated that the evidence of a positive association between green space and better health outcomes was more consistent in areas with trees than grasslands (Nguyen *et al.*, 2021). While cardiometabolic diseases constitute the largest share of the chronic illness burden in the West Bank (Mosleh, 2018), several cross-sectional and longitudinal studies found that tree canopy was negatively associated with these conditions (Kardan *et al.*, 2015; Astell-Burt and Feng, 2020b).

The finding that trees were associated with better health outcomes than non-tree vegetation might be related to several factors. First, trees have added benefits in the possible pathways between green space and health. For example, trees have more advantages in reducing noise, urban heat, flooding and pollution, providing shade, natural soundscape and more visible satisfying greenery than non-tree vegetation (Kardan *et al.*, 2015; Harris *et al.*, 2018; Astell-Burt and Feng, 2020a), especially in high urbanised areas and the relatively hot climate of the Middle East. Trees were found to be particularly important for mental health by promoting physical activity (Mitchell, 2013), sleep (Astell-Burt and Feng, 2020a), and reducing crime (Kondo *et al.*, 2017).

Second, especially in arid climates like the Middle Eastern region, non-tree vegetation tends to be affected by seasonal fluctuations. The lack of rain and water resources only permits such areas to be green around the spring season. In contrast, the resistance and conditioning of trees in such a climate present them as a consistent source of greenery, thus, more health benefits.

Finally, the land covered with trees is a richer habitat for natural biodiversity (e.g., birds and plants) than other forms of green space (e.g., grassland, shrubs). Natural biodiversity is an essential pathway between green space and health and was linked to better psychological restoration and well-being (Wood *et al.*, 2018), microbial diversity and immunity (Rook, 2013; Kuo, 2015) and ecosystem services (Tzoulas *et al.*, 2007).

8.1.4.3 Not all types of tree covers were associated with better health

Another important finding from my research was that not *all* tree classifications were related to the risk of chronic illness. There was no evidence of an association between the proportion of crop 'agricultural' trees in the enumeration areas with the risk of chronic illness.

Three reasons probably work in combination to explain this finding: first, the land covered with crop trees, primarily olive trees, is generally less accessible to residents than other types of trees. They are mainly located in the periphery or enclosed areas, limiting exposure to these green spaces. Additionally, they are usually regarded as personal property, and some families depend on these crops as a source of income (World Bank, 2019b). This is in contrast to other types of trees usually located in the community and residential gardens, streetscapes, and parks, which are more accessible to the public in their daily activities and closer to their homes. Studies have found street trees, for example, were positively associated with better mental and physical health, as they were more accessible to residents than distant natural areas (van Dillen *et al.*, 2012; Kardan *et al.*, 2015; Liu *et al.*, 2020). Crop trees are also smaller and shorter than other types of trees, indicating that they are less visually accessible, for example, from street or window views than other larger trees.

Second, the land covered with crop trees might be considered a poor-quality green space in terms of human contact with nature and ecological quality. The absence of variation in land covered with crop trees makes them less aesthetic and less visually appealing, which might reduce their benefits to health (Harris et al., 2018). These areas usually do not have appropriate street or path lighting, which also brings issues related to safety and could make people avoid them (Maas, 2013). These factors have been highlighted as potentially important in determining the positive experience gained and the beneficial influence of green spaces on population health, especially in terms of restoration of mental health and promoting well-being (van Dillen *et al.*, 2012; Markevych *et al.*, 2017; Nguyen *et al.*, 2021). Moreover, consisting only of one type of tree, lands covered with crop trees bring back the issue of biodiversity discussed above. Compared with lands covered with different kinds of trees with more species diversity.

Finally, green space might be associated with health via harmful pathways. For example, living in areas with a high density of certain types of trees could be related to allergic reactions to pollen, leading to chronic health conditions (Stas *et al.*, 2021). For example, a study conducted in China found that green space was positively associated with chronic obstructive pulmonary disease (Fan *et al.*, 2020). They used NDVI to measure green space and thus could not differentiate between types of green space. However, they suggested that their result might be related to the dominant land cover in their research area. The non-significant association between the proportion of crop trees in the enumeration areas and the risk of chronic illness found in my research might result from a combination of several mediator's effects that act in opposite directions, i.e., neutralise each other.

Main message: My research found that only the proportion of land covered with 'mixed trees' was inversely associated with chronic illness risk. It found no evidence for an association between chronic illness and the proportion of open space and crop trees in the enumeration areas.

8.2 Study two: The analysis of cross-level interaction between the personal and area characteristics in their association with chronic illness

Study one assumed that the magnitude of the association between chronic illness and politically created disadvantage or urban green space was similar across individuals with different characteristics. This assumption is identical to the majority of evidence on the relationship between features of areas of residence and health (Roe *et al.*, 2013; van den Berg *et al.*, 2015; Gascon *et al.*, 2016). However, health is determined by complex individual-environment interactions, and as discussed in chapter three, there are many reasons to challenge such assumptions. For example, people have different exposure patterns (e.g. doses and durations), priorities and experiences, needs, responses and susceptibilities, and orientations to nature (Diderichsen, Hallqvist and Whitehead, 2019). All these factors might create unequal harms/benefits to population health from environmental exposures. Scholars urged addressing the interaction effect between personal attributes and features of the residential setting to understand environmental exposures better and reduce health inequalities (Rodriguez-Loureiro *et al.*, 2021; Bambra, 2022)

Study two addressed this by investigating the interaction between the age, sex, and socioeconomic status (measured by the household assets) of individuals with the characteristics of the residential areas of interest in this research, in their association with the risk of chronic illness. Age, sex, and socioeconomic status are important personal characteristics that reflect how individuals interact with the environment via the mechanisms mentioned above and discussed in detail in chapter two, section 2.2.2. In this section, I will discuss the findings concerning each research question posited in study two.

8.2.1 Does living in the context of a refugee camp interact with age, sex, and household assets in their association with chronic illness?

In chapter three, section 3.2.3, I demonstrated the inconsistency in the evidence of the interaction effect between area disadvantage and demographic and socioeconomic personal characteristics and the reasons for this inconsistency.

This was the first study to investigate the interaction between personal characteristics and living in the disadvantaged context of refugee camps. This research showed evidence of an interaction between living in the disadvantaged context of refugee camps and sex, but not with age and socioeconomic status, in their association with chronic illness. The magnitude of the association between living in refugee camps and the risk of chronic illness was consistent among individuals of different ages and socioeconomic statuses, and the magnitude of the association between age and socioeconomic status with chronic illness does not differ between those living inside or outside refugee camps. The absence of interaction could be a result that people experience or interact with the context of refugee camps similarly regardless of age or socioeconomic status, or because of the low variation in these characteristics between individuals living in refugee camps.

The refugee camp context substantially modified the inverse association between sex (females compared to males) and chronic illness. Contrary to females living outside refugee camps (who had a significantly lower risk of chronic illness compared to males), females living inside refugee camps had a (non-significantly) higher risk of chronic illness. There are three possible explanations for this interaction effect. First, females living outside refugee camps might benefit more from living in advantaged areas than males. In this cultural context, females are likely to spend more time at home, having more caring and domestic responsibilities. Thus, they might spend more time in their residential areas and be more dependent on them in their daily life. Previous studies have found that area disadvantage has a significantly higher impact on females' health than males and that females benefit more from living in advantaged areas (O'Campo et al., 2015; Remes et al., 2017; Stafford et al., 2005). This might explain the sex difference in the disadvantaged context of refugee camps and the more advantageous contexts outside refugee camps.

Second, females in refugee camps are likely to experience multiple vulnerabilities that interact with their disadvantaged context via numerous pathways. For example, the communities in refugee camps are more socially and religiously conservative, posing higher constraints and additional burdens on females, such as more strict gender roles and less freedom (Charles and Denman, 2013; Marshall, 2015). Females living in refugee camps might be more confined to their residential context and have more restricted mobility than their counterparts living outside refugee camps (Marshall, 2015). This further increases the time and dependence on the disadvantaged context of refugee camps and exposes them to higher doses of social and environmental stressors and challenges. Furthermore, they probably encounter more social pressures, stressors, and insecurities, which might be an additional burden affecting health and healthy behaviours such as physical activity. Previous studies have found that females were disproportionally affected by features of the social environment more than males (Kavanagh *et al.*, 2006). A recent study in the oPt highlighted the double burden of females in refugee camps. The unfavourable material and social conditions are compounded by gender inequalities and limited freedom and opportunities (Cavazzoni *et al.*, 2021).

Third, it is plausible that the sex difference between the two contexts is related to the difference in the access or use of health services. For example, the health services provided by the UNRWA in the refugee camps are free of charge, unlike the health system in Ramallah and Albireh (UNRWA, 2021). Despite that, I controlled for the effects of health insurance in the models; the sex difference in the access or use of health services might be higher outside the refugee camps than inside, for example, due to being free of charge in refugee camps, hence creating more differences in terms of those diagnosed with a chronic illness (Tiltnes and Zhang, 2013; Shahin, Kapur and Seita, 2015).

While these reasons are plausible speculations, it would be valuable if future research focuses on such aspects and provides concrete evidence on why there is an interaction effect between sex and refugee camps in their relationship with chronic illness.

Message: There was evidence of an interaction effect between living in the context of refugee camps and sex in their relationship with the risk of chronic illness. There was no significant interaction effect found for age and socioeconomic status (measured by household assets) in their association with the risk of chronic illness.

8.2.2 Does living in the context of areas politically classified 'Area C' interact with age, sex, and socioeconomic status in their association with chronic illness?

The findings revealed no evidence of an interaction effect between living in the disadvantaged context of the land politically classified as 'Area C' and the age, sex, and socioeconomic status of individuals in their association with chronic illness. Thus, the lack of association between living in 'Area C' and the risk of chronic illness holds between individuals regardless of their demographic and socioeconomic differences. Similarly, the magnitude of the association between age, sex and household assets did not change as a function of living in 'Area C' compared to living in 'Area A' and 'Area B'.

It is possible that the absence of an interaction effect between personal characteristics and living in 'Area C' is related to the lack of difference between individuals in the contextual influences or related to the weakness of the main effect of 'Area C' on the probability of chronic illness. As mentioned in section 8.1.3, there was no literature to set against this finding, and further research with a broader geographical area is needed to confirm the evidence of no significant interaction effect between age, sex and socioeconomic status and living in the context of the disadvantaged context of 'Area C' in their interaction with the risk of chronic illness.

Main message: There was no evidence of an interaction effect between political land classification and personal characteristics (age, sex, and socioeconomic status) in their relationship with the risk of chronic illness.

8.2.3 Does the proportion of 'mixed trees' in the areas of residence interact with age, sex, and household assets in their association with chronic illness?

I only investigated the interaction between the proportion of mixed trees in the enumeration areas and personal characteristics. As mentioned in section 7.2.2, the models did not have the power to investigate the interaction between the proportion of open space and crop trees in the enumeration areas and personal attributes in their association with chronic illness.

The interaction between age, sex and socioeconomic status with urban green space has not been studied often and rarely all within one study (Sillman *et al.*, 2022). The findings in this research demonstrated no evidence of an interaction effect between age, sex and household assets and the proportion of mixed trees in the enumeration areas in their relationship with chronic illness. The findings indicated that the benefit of mixed trees in residential areas in reducing the risk of chronic illness was identical regardless of these personal characteristics. Perhaps the effect of mixed trees was strong for everyone, or these personal characteristics did not capture possible differential benefits of mixed trees to health.

Several studies about the links between green space and health had similar findings (Van den Berg *et al.*, 2016; Wood *et al.*, 2018; Shin *et al.*, 2020; Hong *et al.*, 2021). However, my findings were in contrast with several other previous studies. For example, some studies showed an interaction effect between green space and demographic indicators (age and sex) (Maas et al., 2009; Richardson & Mitchell, 2010; Sander, Ghosh, & Hodson, 2017; Sarkar, Webster, & Gallacher, 2018). Other studies showed an interaction effect between green space and socioeconomic indicators (Maas *et al.*, 2006; McEachan *et al.*, 2016; Reid *et al.*, 2017; Tomita *et al.*, 2017). As mentioned in chapter three, the different measures of green space, the complexity of the interaction between green space and the personal attributes in their association with health outcomes and the diversity of mediators between them prevent the comparison between studies.

Some new evidence is emerging from Global Positioning System and accelerometer data, in addition to qualitative data, which all may offer a better understanding of the complexity of the relationships between personal attributes and exposure and use of urban green space, and between regular contact with these spaces within contexts (Bell, Phoenix, Lovell, & Wheeler, 2015; D. T. Duncan & Kawachi, 2018; Holland et al., 2021).

Main message: There was no evidence of an interaction between the proportion of mixed trees in the residential areas with age, sex, and socioeconomic status in their association with chronic illness.

8.3 A reflection on the multi-level methods

As discussed in chapter two, distilling the features of places to a handful of contextual variables will not capture the whole complexity of the 'area effect', which perhaps includes numerous unidentified and intertwined processes connecting people with places. Investigating the dynamic processes between people and places using conventional quantitative methods remains limited and will not capture the complexity of the relationship in detail (Mitchell, 2001). Other methods, such as qualitative interviews, network analysis, and the 'Global Positioning System' (GPS), may complement and enrich the understanding of this complexity (Cummins et al., 2007; Duncan, Goedel, & Chunara, 2018). For example, qualitative studies provided valuable insights into how compositional factors such as selective migration and health can change places by drawing people into and out of healthy or unhealthy places and influencing health inequality (Smith & Easterlow, 2005).

On balance, I believe the distinction between the contextual and the compositional components had a practical appeal that provided a useful framework for posing questions about the sources of variation in health. It helped understand and unpack the role of places in shaping the population's health. It was necessary to account for important individual factors that could bias the results about the possible impacts of physical environment features on individuals' health. Explicit theorising and controlling for intervening variables attributed the variation in health to factors embedded in the environment and independent of people (Duncan, Jones and Moon, 1998; Subramanian, Kawachi and Kennedy, 2001).

The multi-level methodology accounted for the dependency between individuals sharing common characteristics with others in the same residential area. Investigating the cross-level interactions between personal characteristics and features of residential areas enabled a closer investigation of the complexity between people and places and potential inequalities related to a combination of personal and contextual determinants of health.

8.4 Strengths

The novel setting was a key strength of this research. Few studies have investigated health with the characteristics of residential areas, including green space, in the Middle Eastern Arab region, and this was the first in oPt. Hence it begins to fill a gap in the literature about such contexts. Furthermore, including the political classification along with the physical characteristics of the residential areas as a unique constituent of the oPt allowed me to compare the literature from other settings to assess the importance or the unimportance of local-specific features.

This research used the best available data about the population and the environment. The analysis was based on census data that covered almost all the people of the twin cities with a 94.8% response rate and controlled for several critical individual-level confounders to the relationship between area characteristics and health. Using an up-to-date and comprehensive measure of green space quantity and type was a key strength. The high-resolution green space map for small areas provided a geocoded quantitative description of *all* the green space in the enumeration areas. I conducted a fine-scale review and edit of these data to ensure spatial and temporal accuracy. Many previous studies used low to moderate-resolution vegetation indices to measure green space, such as NDVI. These measures do not capture small patches of green space (such as street trees) (Markevych *et al.*, 2017; Kondo *et al.*, 2018; Liu *et al.*, 2020). These might be particularly relevant to the Middle Eastern context as they constitute most of the greenery, especially in highly urbanised areas, in contrast to countries of the global North. Separating different forms of green space (open space, crop trees and mixed trees) in this research was important and answered multiple calls (Wheeler *et al.*, 2015; Zupancic, Westmacott and Bulthuis, 2015; Markevych *et al.*, 2017; Reid *et al.*, 2017; Labib, Lindley and Huck, 2019).

8.5 Limitations

The study was subject to the limitations of all observational cross-sectional studies in terms of causal inference. It was not possible to ascertain that the associations observed in this research were causal because they did not satisfy the criteria for causal inference. These include the temporality in the relationship between exposure and outcome and potentially biased estimation of the effects due to direct selection. Temporality refers to ensuring that the exposure preceded the health outcome. Direct selection is when people with specific characteristics move to or migrate to certain areas. The results did suggest a life course effect of living in a refugee camp by highlighting those who had previously lived there having higher odds of chronic disease compared to others of similar individual/household characteristics, but further longitudinal research is required to confirm this.

As with many studies using area-level measures, the study was subject to the "uncertain geographic context problem" because it relied on administrative boundaries that were not designed for research purposes (Kwan, 2012). The assumption was that the areal residence units adequately captured individuals' exposure to their environment and that people had equal access to environmental features. However, these could differ from individual-level exposures and what the residents experience and face daily (Voigtländer, Razum and Berger, 2013). For example, the daily mobility and work environment were not considered in this research, which might be essential factors in environmental exposures. Using the proportion of green space in the residential areas forced me to assume that people had equal exposure and access to these areas. However, there was no available data on mobility or distance to account for these factors. Another limitation in using fixed admirative boundaries is the comparability with other studies. Areas with different sizes might capture different environmental aspects. Using egocentric measures such as homogeneous buffer zones around the location of residence was not possible in this study because geocoded information about the home location was unavailable.

This research did not consider the quality of green space, how people experience it, and how people relate to disadvantaged contexts. The green space measure adopted in this research might not be relevant for all possible pathways between green space and health (for example, physical activity). Data on other aspects of the urban environment, such as green space connectivity, street walkability, air pollution and traffic, were not available and thus were not accounted for. All these factors might be related to health outcomes and interact with area-level features such as green space; therefore, adding them would have provided valuable information to understand further the links between area characteristics and their quality and health outcomes (Nguyen *et al.*, 2021).

The health outcome in this research was based on a self-reported measure for chronic illness, which might differ from the actual health outcome. The study might have missed those suffering from undiagnosed/unmedicated chronic diseases. Finally, the health outcome encompassed a variety of chronic illnesses that could have different environmental pathways, but specific diagnosed conditions were not available.

8.6 Implications and recommendations

While acknowledging the limitations of this research, it highlighted the importance of the context of residential areas in shaping the health of the population in the Middle Eastern Arab region. It provided an understanding that addressing the urban physical environment is important in promoting health and preventing diseases in contexts that suffer from multiple political, social, and environmental problems.

This research supports the social-ecological model of health within complex Middle Eastern settings and acknowledges that population health and well-being are inseparable from environmental and political improvement. Promoting public health is only effective and sustainable when it addresses both the individual and the environment. Thus, politicians, policymakers, researchers, planners, and the public should collaborate to implement environments supportive of health and equality. In this section, I will discuss the implication and recommendations of this thesis for policy and research.

8.6.1 The implications of the findings

The findings from study one provided evidence that living in the context of refugee camps was positively related to worse odds of chronic illness and that individuals with a refugee background (previously lived in refugee camps) suffer from higher odds of chronic illness. Green space explained the harmful context of refugee camps to health. Thus, this research support local and international efforts and advocacy that target solving the refugee problem and improving conditions within refugee camps. Environmental interventions could support the population's health in refugee camps, such as increasing green spaces, especially mixed trees.

Study one also suggested that the benefits of urban greenspace for health, from the dominant Global North literature, may hold similar benefits in the Arab World. It showed that the proportion of mixed trees in residential areas was positively associated with better health outcomes. This finding can aid policymakers and urban planners interested in the positive impact of urban greening on the population's health in considering protecting, maintaining, and increasing mixed trees in the twin cities and beyond.

In the oPt, there is a national policy called 'Keep Palestine Green' that aims to "conserve biodiversity, establish nature preserves and expand green spaces". However, the planning regulations in the oPt have failed to support actions to promote, manage and maintain green and public spaces in urban settings, and these actions were not integrated into the planning system (UNEP, 2020). The evidence in this research supports implementing these greening policies and integrating them with initiatives and incentives in the national public health and planning strategies. These actions should be accompanied by more advocacy, funding, and a vision to create healthier and greener cities that support health and well-being, reduce health inequalities, and mitigate climate change in the oPt and beyond.

This research suggests that converting open spaces into gardens and lands planted with mixed trees and greening streets could benefit the population. For example, a meta-narrative review of intervention studies found that greening vacant lots and planting street trees in urban areas was associated with better health (Hunter et al., 2019). Initiatives and policies such as these can have positive outcomes. For example, Scotland has a policy for repurposing vacant and derelict land (Scottish Land Commission, 2020), and piloting similar approaches in the Middle-Eastern Arab context is recommended.

These investments should not exclude refugee camps; otherwise, they will further aggravate the already entrenched social inequalities in health across the oPt and the Arab World. Two further noteworthy challenges with refugee camps are the political complexity in addressing refugee camps and the high density of built structures. Planting trees or changing the built form of refugee camps can be perceived as an acceptance of their permanence. It might be convenient to aim attention to their multiple benefits for health when advocating tree planting to authorities, organisations, and the public, with a political approach to the framework of the right to health. Community engagement and participation is a key to addressing these challenges. There are some examples of greening initiatives that were implemented successfully in refugee camps that can be learned from and applied in the Palestinian and other contexts. For example, initiatives in Iraq (Perkins, Adam-Bradford and Tomkins, 2017) and Australia (Harris, Minniss and Somerset, 2014). Highly dense areas that lack available space, either in refugee camps or other parts of cities, require innovative nature-based solutions and planning. Roof greening and vertical green infrastructure might be good examples (Haaland and van den Bosch, 2015).

However, single interventions are often ineffective in improving health and preventing chronic disease across sociodemographic groups, and a range of interventions and a multi-disciplinary approach is required to maximise the benefits (UN-Habitat, 2020; Romanello *et al.*, 2021). The findings of this research implied that green infrastructure should be included as part of a portfolio of long-term policy perspectives to improve population health. Creating a health-supportive environment is a complicated endeavour, especially in the Palestinian case, with multiple intertwined challenges emanating from the Israeli military occupation, such as impaired sovereignty, lack of natural resources and a crippled economy. Tackling these challenges to promote health and prevent disease requires a holistic structural and bottom-up approach.

The findings from study two highlighted the interaction effect between sex and refugee camps and the higher negative impact of the disadvantaged context of refugee camps on females. This knowledge can be used to target females who might benefit more from future advocacy, policies and interventions that aim to change the status quo or improve the context of refugee camps. Study two also demonstrated the universal benefit of policies and interventions to promote, protect and maintain mixed trees in residential areas regardless of personal characteristics.

8.6.2 Recommendations for future research in the Middle East and the oPt

My research was among a few investigating the links between the urban environment and health in the Middle Eastern Arab region context. Its results suggest several research questions for future research to enrich the literature from this understudied region:

Are 'mixed trees' in residential areas causally related to health outcomes? What are the pathways between green space and health outcomes, and how do they interact with personal characteristics?

Future research needs to adopt experimental, quasi-experimental and longitudinal designs to confirm a causal relationship between health outcomes and mixed trees in residential areas. The next Palestinian census in 2027 could be an excellent opportunity to look at change over time, or if the PCBS shares the data from the previous 2007 census, with the caveat of only two/three time points. Future work should include social, environmental, and behavioural factors on the pathways between green space and health, such as air pollution, urban heat, and physical activity, since they are related to and interact with green space and personal characteristics. This can help us more fully understand the findings in my research on essential pathways between 'mixed trees' and health and the specific factors responsible for the no association between health and crop trees and green space without trees. This can also help clarify the finding that green space explains the harmful effects of refugee camps on health.

Does individual-level exposure to mixed trees have a beneficial impact on health?

This research used the availability of mixed trees in residential areas and assessed their association with health. One limitation in using residential areas as the unit of analysis is that they might not correspond to the individual-level mobility and time spent outside their residential areas. Individual-level mobility patterns and accessibility measures for green space are needed to confirm and complement the finding of this research. Multi-scale approaches and methods using the Global Positioning System (GPS) alongside geographic data to track the locations of individuals and durations of exposure have growing popularity in Western settings (Bell *et al.*, 2015; Collins *et al.*, 2020). These can better capture individuals' daily exposures to green space and better understand the access and use of green space. GPS can also be used with technologies that assess physical activity, heart rate and other health indicators and healthy/unhealthy behaviours (for example, through smart watches), which can provide further detailed information that can be used in future research.

How do individuals experience green space and the disadvantaged contexts of refugee camps?

The input from the residents is critical to gaining a more comprehensive understanding of the relationship between places and health. There is a need for more qualitative studies that seek to understand their experiences, responses, adaptation and challenges in their daily lives and the characteristics of residential areas. Understanding these aspects with green space and disadvantaged contexts such as refugee camps can provide a clearer picture. It can make small steps of change possible, given the considerable impediments to changing the environment. It could also support future interventions to understand how people in these different areas view, use, access and feel about these spaces.

8.7 Conclusion

Based on the best data available and within the confines of a cross-sectional, observational study, the findings shed light on the possible role of the urban environment in the occupied Palestinian territory as a determinant of health, irrespective of individual-level factors. This study contributes to the literature on the relationship between the urban environment and health within developing countries by providing evidence from a different and understudied climatic, political, and cultural setting of the Arab World.

In general, the findings of this study support the international evidence about the harmful effects of refugee camps on health. A political approach to the right-to-health framework is needed to find solutions, end the refugee camps issue, and address these disadvantaged contexts in the oPt and beyond. This study also supports the evidence about the universality of trees as beneficial to population health. It highlighted that the type of green space matters for health. Areas with a higher proportion of 'mixed trees' were associated with lower levels of chronic disease, irrespective of individual-level factors. These findings highlighted the importance of differentiating between types of green space to decipher better and assess the potential protective influence of green space and population health, mainly how this might vary within rapidly developing and arid contexts.

This study highlighted the importance of the broader social, environmental, and political determinants of health. It showed that various individual, area-level, and ecological factors influence health in conflict areas and refugees. Addressing the adversity associated with living in politically created contexts of refugee camps on health requires a wide range of interventions (including environmental) to support health and reduce health inequalities. This research stressed green space in refugee camps as an important component in strategies to prevent diseases and reduce health inequalities, with more attention to females in this disadvantaged context.

Finally, the main message to researchers, policymakers and urban planners in the oPt and the rest of the world is to focus attention on disadvantaged contexts because of the negative influence that these contexts exert on the health of its residents. Efforts should protect and increase the areas with mixed trees, given the positive impact on public health, as part of a portfolio of long-term policy perspectives to improve population health. An interdisciplinary approach to public health problems is needed to promote population health and well-being and eliminate health disparities.

Appendices

A. Detailed literature search results

I conducted two literature searches, one for international literature and one for the literature in the Arab World. In this appendix, I will present each step of the literature search and the results from the two literature searches in the four databases.

1. Search for reviews in the international literature

The search in the international literature was restricted to reviews in the four databases. The following tables describe the search steps and the results from the four databases.

Table 9-1:Search for reviews in the Medline database through the OVID platform in 5/5/21

#	*Search terms*	*Results*	*Description*
1	Mental health/ or Public health/ or Health status/ or Morbidity/	322626	MeSH terms
2	(chronic disease* or chronic illness* or morbidity or mortality or Death or "physical health" or "general health" or "self-reported health" or "mental illness*" or "mental health" or non-communicable disease* or morbidity or physical illness or mental illness* or wellbeing or well-being or heart disease* or hypertens* or blood pressure or Diabet* or Asthma or stroke or cancer*).ti.	2095081	Title
3	**#1 OR #2**	2287500	
4	(neighborhood* or neighbourhood* or area-level or "area level" or places or place-based or "residential area" or "residential areas" or "urban area" or "urban areas" or "urban environment" or "natural environment").ti.	15915	Title
5	(greenspace* or "green space" or "green spaces" or "green environment" or "open space" or "open spaces" or "open public space" or "green area" or "green areas" or greenery or vegetation or "land	27837	Title

	cover" or "tree cover" or "urban trees" or forest* or woodland* or parks or gardens).ti.		
6	("political class" or "political classification" or "refugee camp" or "refugee camps").ti.	397	Title
7	**#4 OR #5 OR #6**	529306	
8	(Review or Meta-analysis).ti.	109933	Title
9	review/	2679245	MeSH terms
10	**#8 OR #9**	2893341	
11	**#3 AND #7 AND #10**	**193**	

Table 9-2: Search for reviews in Embase database through OVID platform in 6/5/21

#	*Search terms*	*Results*	*Description*
1	Mental health/ or Public health/ or Health status/ or Morbidity/	880078	MeSH terms
2	(chronic disease* or chronic illness* or morbidity or mortality or Death or "physical health" or "general health" or "self-reported health" or "mental illness*" or "mental health" or non-communicable disease* or morbidity or physical illness or mental illness* or wellbeing or well-being or heart disease* or hypertens* or blood pressure or Diabet* or Asthma or stroke or cancer*).ti.	3313374	Title
3	**#1 OR #2**	4026213	
4	(neighborhood* or neighbourhood* or area-level or "area level" or places or place-based or "residential area" or "residential areas" or "urban area" or "urban areas" or "urban environment" or "natural environment").ti.	21912	Title
5	(greenspace* or "green space" or "green spaces" or "green environment" or "open space" or "open spaces" or "open public space" or "green area" or "green areas" or greenery or vegetation or "land cover" or "tree cover" or "urban trees" or forest* or woodland* or parks or gardens).ti.	38336	Title
6	("political class" or "political classification" or "refugee camp" or "refugee camps").ti.	525	Title
7	**#4 OR #5 OR #6**	60498	
8	(Review or Meta-analysis).ti.	784976	Title
9	review/	2755619	MeSH terms
10	**#9 OR #11**	3231988	
11	**#3 AND #7 AND #10**	**286**	

Table 9-3:Search for reviews in the International Bibliography of the Social Sciences database through the Proquest platform in 6/5/21

#	Search terms	Results	Description
1	**ti(**chronic disease* or chronic illness* or morbidity or mortality or Death or "physical health" or "general health" or "self-reported health" or "mental illness*" or "mental health" or non-communicable disease* or morbidity or physical illness or mental illness* or wellbeing or well-being or heart disease* or hypertens* or blood pressure or Diabet* or Asthma or stroke or cancer***)**	55155	Title
2	ti(neighborhood* or neighbourhood* or area-level or "area level" or places or place-based or "residential area" or "residential areas" or "urban area" or "urban areas" or "urban environment" or "natural environment")	34936	Title
3	ti(greenspace* or "green space" or "green spaces" or "green environment" or "open space" or "open spaces" or "open public space" or "green area" or "green areas" or greenery or vegetation or "land cover" or "tree cover" or "urban trees" or forest* or woodland* or parks or gardens)	18911	Title
4	ti("political class" or "political classification" or "refugee camp" or "refugee camps")	536	Title
5	**2 OR 3 OR 4**	54067	
6	ti(Review or Meta-analysis)	172857	Title
7	**1 AND 5 AND 6**	**14**	

Table 9-4: Search for reviews in the Social Science Citation indexes database through the Web of Science platform in 6/5/21

#	Search terms	Results	Description
1	chronic disease* or chronic illness* or morbidity or mortality or Death or "physical health" or "general health" or "self-reported health" or "mental illness*" or "mental health" or non-communicable disease* or morbidity or physical illness or mental illness* or wellbeing or well-being or heart disease* or hypertens* or blood pressure or Diabet* or Asthma or stroke or cancer*	381416	Title
2	neighborhood* or neighbourhood* or area-level or "area level" or places or place-based or "residential area" or "residential areas" or "urban area" or "urban areas" or "urban environment" or "natural environment"	52128	Title
3	greenspace* or "green space" or "green spaces" or "green environment" or "open space" or "open spaces" or "open public space" or "green area" or "green areas" or greenery or vegetation or "land cover" or "tree cover" or "urban trees" or forest* or woodland* or parks or gardens	39764	Title
4	“political class" or "political classification" or "refugee camp" or "refugee camps”	509	Title
5	**2 OR 3 OR 4**	91623	
6	Review or Meta-analysis	185043	
7	**1 AND 5 AND 6**	**99**	

2. Search for literature in the Arab World

In the following tables, I present the steps and results of the literature search in the Arab World in the four databases.

Table 9-5: Search for literature in the Arab world in Medline database through OVID interface in 5/5/21

#	Search terms	Results	Description
1	Mental health/or Public health/or Health status/ or Morbidity/	232626	MeSH terms
2	**(disease* OR illness* OR morbidity OR chronic* OR illness OR Patholog* OR syndrome OR disorder* OR mortality OR Death OR physical health OR general health OR self-reported health OR population health OR hypertens* OR blood pressure OR Diabet* OR Asthma OR stroke OR cancer* OR neoplasm* OR pain OR obesity OR body mass index OR BMI OR psychological illness* OR psychological disorder* OR mental illness* OR mental health OR Wellbeing OR well-being OR quality of life OR QOL OR life satisfaction OR stress OR anxiety OR depression) .ab,ti,sh.**	10366109	Title, abstract and subheading
3	**#1 OR #2**	10443636	
4	Parks, Recreational/ or Residence Characteristics/ or City Planning/	38570	MeSH terms
5	**(built environment* OR neighborhood* OR neighbourhood* OR contextual OR spatial OR ecological OR area-level OR area level OR Geographical Information system OR GIS OR physical environment OR residential area* OR urban design OR (urban ADJ3 quality) OR (urban ADJ3 infrastructure) OR (urban ADJ3 environment) OR urban planning OR city planning OR urban heat OR (natural ADJ3 environment*) OR Greenspace* OR (green ADJ3 space*)OR (green ADJ3 environment) OR (open ADJ3 space*) OR (open ADJ3 space*) OR (green ADJ3 area*) OR greenery OR (green ADJ3 vegetation) OR land cover OR land use* OR tree cover OR urban trees OR urban forest* OR woodland* OR public park* OR gardens OR "political class*" OR refugee camp*) .ab,ti,sh.**	409669	Title, abstract and subheading
6	**#4 OR #5**	434709	
7	(Palestine or Palestinian* or Occupied Palestinian territory or West Bank or Gaza).ab,ti,sh.	3006	Title, abstract and subheading
8	**#3 AND #6 AND #7**	**140**	**Search 1**
9	**(Middle East OR North Africa OR MENA OR Arab world OR Arab region OR Arab countries OR Jordan OR Egypt OR Lebanon OR Syria OR Tunisia OR Morocco OR Libya OR Algeria OR Sudan OR Iraq OR Saudi Arabia OR Kuwait OR Qatar OR United Arab Emirates OR UAE OR Oman OR Yemen) .ab,ti,sh.**	109933	Title, abstract and subheading
x	**#3 AND #6 AND #9**	**1165**	**Search 2**

Table 9-6: Search for literature in the Arab world in Embase database through the OVID interface in 6/5/21

#	Search terms	Results	Description
1	**(disease* OR illness* OR morbidity OR chronic* OR illness OR Patholog* OR syndrome OR disorder* OR mortality OR Death OR physical health OR general health OR self-reported health OR population health OR hypertens* OR blood pressure OR Diabet* OR Asthma OR stroke OR cancer* OR neoplasm* OR pain OR obesity OR body mass index OR BMI OR psychological illness* OR psychological disorder* OR mental illness* OR mental health OR Wellbeing OR well-being OR quality of life OR QOL OR life satisfaction OR stress OR anxiety OR depression) .ab,ti,sh.**	17778903	Title, abstract and subheading
2	**(built environment* OR neighborhood* OR neighbourhood* OR contextual OR spatial OR ecological OR area-level OR area level OR Geographical Information system OR GIS OR physical environment OR residential area* OR urban design OR (urban ADJ3 quality) OR (urban ADJ3 infrastructure) OR (urban ADJ3 environment) OR urban planning OR city planning OR urban heat OR (natural ADJ3 environment*) OR Greenspace* OR (green ADJ3 space*)OR (green ADJ3 environment) OR (open ADJ3 space*) OR (open ADJ3 space*) OR (green ADJ3 area*) OR greenery OR (green ADJ3 vegetation) OR land cover OR land use* OR tree cover OR urban trees OR urban forest* OR woodland* OR public park* OR gardens OR refugee camp*) .ab,ti,sh.**	597986	Title, abstract and subheading
3	(Palestine or Palestinian* or Occupied Palestinian territory or West Bank or Gaza).ab,ti,sh.	5192	Title, abstract and subheading
4	#3 AND #6 AND #7	**195**	**Search 1**
5	**(Middle East OR North Africa OR MENA OR Arab world OR Arab region OR Arab countries OR Jordan OR Egypt OR Lebanon OR Syria OR Tunisia OR Morocco OR Libya OR Algeria OR Sudan OR Iraq OR Saudi Arabia OR Kuwait OR Qatar OR United Arab Emirates OR UAE OR Oman OR Yemen) .ab,ti,sh.**	172099	Title, abstract and subheading
6	**#3 AND #6 AND #9**	**1430**	**Search 2**

Table 9-7: Search for literature in the Arab world in International Bibliography of the Social Sciences through ProQuest interface in 6/5/21

#	Search terms	Results	Description
1	**noft(disease* OR illness* OR morbidity OR chronic* OR illness OR Patholog* OR syndrome OR disorder* OR mortality OR Death OR physical health OR general index OR BMI OR psychological illness* OR psychological disorder* OR mental illness* OR mental health OR Wellbeing OR well-being OR quality of life OR QOL OR life satisfaction OR stress OR anxiety OR depression)**	337433	Anywhere except full text
2	**noft(built environment* OR neighborhood* OR neighbourhood* OR contextual health OR self-reported health OR population health OR hypertens* OR blood pressure OR Diabet* OR Asthma OR stroke OR cancer* OR neoplasm* OR pain OR obesity OR body mass OR spatial OR ecological OR area-level OR area level OR Geographical Information system OR GIS OR physical environment OR residential area* OR urban design OR (urban N3 quality) OR (urban N3 infrastructure) OR (urban N3 environment) OR urban planning OR city planning OR urban heat OR (natural N3 environment*) OR Greenspace* OR (green N3 space*)OR (green N3 environment) OR (open N3 space*) OR (open N3 space*) OR (green N3 area*) OR greenery OR (green N3 vegetation) OR land cover OR land use* OR tree cover OR urban trees OR urban forest* OR woodland* OR public park* OR gardens OR refugee camp*)**	254216	Anywhere except full text
3	noft(Palestine or Palestinian* or Occupied Palestinian territory or West Bank or Gaza)	27918	Anywhere except full text
4	**1 AND 2 AND 3**	**229**	**oPt**
5	**noft(Middle East OR North Africa OR MENA OR Arab world OR Arab region OR Arab countries OR Jordan OR Egypt OR Lebanon OR Syria OR Tunisia OR Morocco OR Libya OR Algeria OR Sudan OR Iraq OR Saudi Arabia OR Kuwait OR Qatar OR United Arab Emirates OR UAE OR Oman OR Yemen)**	170039	Anywhere except full text
6	**1 AND 2 AND 5**	**965**	**Arab world**

Table 9-8: Search for literature in the Arab world in Social Science Citation indexes through the Web of Science platform in 6/5/21

#	Search terms	Results	Description
1	**(disease* OR illness* OR morbidity OR chronic* OR illness OR Patholog* OR syndrome OR disorder* OR mortality OR Death OR physical health OR general health OR self-reported health OR population health OR hypertens* OR blood pressure OR Diabet* OR Asthma OR stroke OR cancer* OR neoplasm* OR pain OR obesity OR body mass index OR BMI OR psychological illness* OR psychological disorder* OR mental illness* OR mental health OR Wellbeing OR well-being OR quality of life OR QOL OR life satisfaction OR stress OR anxiety OR depression)**	1837849	Topic (includes title, abstract, keywords and keywords plus)
2	**(built environment* OR neighborhood* OR neighbourhood* OR contextual OR spatial OR ecological OR area-level OR area level OR Geographical Information system OR GIS OR physical environment OR residential area* OR urban design OR (urban NEAR/3 quality) OR (urban NEAR/3 infrastructure) OR (urban NEAR/3 environment) OR urban planning OR city planning OR urban heat OR (natural NEAR/3 environment*) OR Greenspace* OR (green NEAR/3 space*)OR (green NEAR/3 environment) OR (open N3 space*) OR (open NEAR/3 space*) OR (green NEAR/3 area*) OR greenery OR (green NEAR/3 vegetation) OR land cover OR land use* OR tree cover OR urban trees OR urban forest* OR woodland* OR public park* OR gardens OR refugee camp*)**	488858	Topic
3	(Palestine or Palestinian* or Occupied Palestinian territory or West Bank or Gaza)	11898	Topic
4	**1 AND 2 AND 3**	**267**	**oPt**
5	**(Middle East OR North Africa OR MENA OR Arab world OR Arab region OR Arab countries OR Jordan OR Egypt OR Lebanon OR Syria OR Tunisia OR Morocco OR Libya OR Algeria OR Sudan OR Iraq OR Saudi Arabia OR Kuwait OR Qatar OR United Arab Emirates OR UAE OR Oman OR Yemen)**	73846	Topic
6	**1 AND 2 AND 5**	**1535**	**Arab World**

B. Summary of the studies found in the Arab World

Year	Author	Setting	Outcome	Area-level variable	Quality
2011	Mowafi et al.	Cairo, Egypt	BMI	Percentage of households with individuals educated more than high school level	Multi-level study with high quality
2012	Mowafi et al.	Cairo, Egypt	BMI	Several indicators of Green space	Multi-level study with high quality
2013	Ahmad et al.	Aleppo, Syria	Self-reported general health	% illiterate, % unemployed, average household wealth, % housing density, % people with no car, and formality status	Good Quality but might be subject to over-adjusting of relatively similar area-level variables
2016	Sidawi et al.	Al-Khobar, Saudi Arabia	Density of lipoprotein	Perception of the neighbourhood's unpleasant views	Low quality, very small sample size (76) and did not account for area effects
2017	Bates et al.	The oPt	Self- rated health, acute and chronic diseases	None; it was selected because it reports the variation in health between areas in the oPt	A high-quality multi-level study covering the whole population of the oPt
2019	Algoday et al.	Alexandria, Egypt	BMI	The State of Place index	Low Quality: Based on unreliable individual-level data and not

					generalisable as it studied only two neighbourhoods
2020	Afrad and Kawazoe	Tangier, Morocco	Depression measured using the Patient Health Questionnaire	ownership and interaction with potted street gardens	Low quality: high selection bias (70% of the sample are males without controlling for economic variables), small sample size, and only three areas
2020	Saddik et al.	Al Riyadh, Saudi Arabia	Self-reported depressive symptoms	perceived walkability, aesthetics, safety, and connectedness	Low quality: they did not account for the clustering effects in different areas.

C. R packages used in the thesis

In the data analysis of this thesis, I used several functions and packages in R software. Table 9-9 presents these functions and packages and their citation.

Table 9-9: R functions and their packages used in the thesis

Function/s	Description	Package	Citation
Read.spss	Reading SPSS data into R	foreign	R Core Team (2020). foreign: Read Data Stored by 'Minitab', 'S', 'SAS', 'SPSS', 'Stata', 'Systat', 'Weka', 'dBase', ... R package version 0.8-80. https://CRAN.R-project.org/package=foreign
ggplot and other sub-functions of	Data visualisation	ggpolt2	H. Wickham. ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York, 2016.

ggplot2 package			
rename	Renaming the variables	reshape	H. Wickham. Reshaping data with the reshape package. Journal of Statistical Software, 21(12), 2007.
St_write, as_spatial, plot_sf, read_sf and other sub-functions of sf package	Simple Features for R: Standardised Support for Spatial Vector Data	sf	Pebesma, E., 2018. Simple Features for R: Standardised Support for Spatial Vector Data. The R Journal 10 (1), 439-446, https://doi.org/10.32614/RJ-2018-009
describe	Summaries for the variables	psych	Revelle, W. (2020) psych: Procedures for Personality and Psychological Research, Northwestern University, Evanston, Illinois, USA, https://CRAN.R-project.org/package=psych Version = 2.0.9,.
tetrachoric	tetrachoric correlation matrix		
car. plot	heat map for the correlation matrix		
principal	principal component analysis		
parallel	scree plot of the parallel analysis	nFactors	Gilles Raiche and David Magis (2020). nFactors: Parallel Analysis and Other Non Graphical Solutions to the Cattell Scree Test. R package version 2.4.1. https://CRAN.R-project.org/package=nFactors
Mutate, select, filter, summarise, arrange, groupby, join, left_join, tally, na_if, ifelse, recode_factor, as_tibble	Data manipulation	dplyr	Hadley Wickham, Romain François, Lionel Henry and Kirill Müller (2021). dplyr: A Grammar of Data Manipulation. R package version 1.0.7. https://CRAN.R-project.org/package=dplyr
n_miss, prop_miss, viss_miss, gg_miss	Summaries and visualisation of missing data	naniar	Nicholas Tierney, Di Cook, Miles McBain and Colin Fay (2021). naniar: Data Structures,

			Summaries, and Visualisations for Missing Data. R package version 0.6.1. https://CRAN.R-project.org/package=naniar
glmer	Multi-level modelling	Lme4	Douglas Bates, Martin Maechler, Ben Bolker, Steve Walker (2015). Fitting Linear Mixed-Effects Models Using lme4. Journal of Statistical Software, 67(1), 1-48. doi:10.18637/jss.v067.i01.
icc	Interclass correlation coefficient	performance	Lüdecke, Makowski, Waggoner & Patil (2020). Assessment of Regression Models Performance. CRAN. Available from https://easystats.github.io/performance/
r2_nakagawa	Nakagawa's R squared for mixed models		
r.squaredGLMM	Pseudo R squared for generalised linear multi-level models	MuMIn	Kamil Barton (2020). MuMIn: Multi-Model Inference. R package version 1.43.17. https://CRAN.R-project.org/package=MuMIn
vif	Variance Inflation Factor	car	John Fox and Sanford Weisberg (2019). An {R} Companion to Applied Regression, Third Edition. Thousand Oaks CA: Sage. URL: https://socialsciences.mcmaster.ca/jfox/Books/Companion/
Plot_model	Plotting and visually testing the normal distribution of the random effect	sjPlot	Lüdecke D (2020). _sjPlot: Data Visualization for Statistics in Social Science_. R package version 2.8.6, <URL: https://CRAN.R-project.org/package=sjPlot>.
ggpredict	Marginal effects and estimated marginal means from the regression models	ggeffects	Lüdecke D (2018). "ggeffects: Tidy Data Frames of Marginal Effects from Regression Models." Journal of Open Source Software, *3*(26), 772. doi: 10.21105/joss.00772 (URL: https://doi.org/10.21105/joss.00772).

SimulateResiduals	simulates scaled residuals from fitted logistic models and examines their residuals' distribution	DHARMa	Florian Hartig (2020). DHARMa: Residual Diagnostics for Hierarchical (Multi-Level / Mixed) Regression Models. R package version 0.3.3.0. https://CRAN.R-project.org/package=DHARMa
plot residuals	Residuals diagnostics for the generalised linear multi-level regression		
missing_pairs	Exploring missing values	finalfit	Ewen Harrison, Tom Drake and Riinu Ots (2021). finalfit: Quickly Create Elegant Regression Results Tables and Plots when Modelling. R package version 1.0.4. https://CRAN.R-project.org/package=finalfit
anova	likelihood ratio test	stats, base	R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.
load	Load R data		
subset	Create a subset		
duplicated	Determine duplicated elements		
cbind	Combine objects by rows and columns		
save	Save data		
merge	Merge two data frames		
lapply	Apply a function over lists or vectors		
paste	Concatenate vectors after converting to a character.		
cut	Convert a numeric variable to a factor		
table, prop.table	Tables and proportions		
update	Update and refit a model call		
predict	Model predictions		

confit	Confidence intervals for parameters of the models		

D. Maps of all the land cover categories in the twin cities of Ramallah and Albireh

Below are the maps of all the land cover categories showing the proportion of each type of land cover in enumeration areas of the twin cities of Ramallah and Albireh.

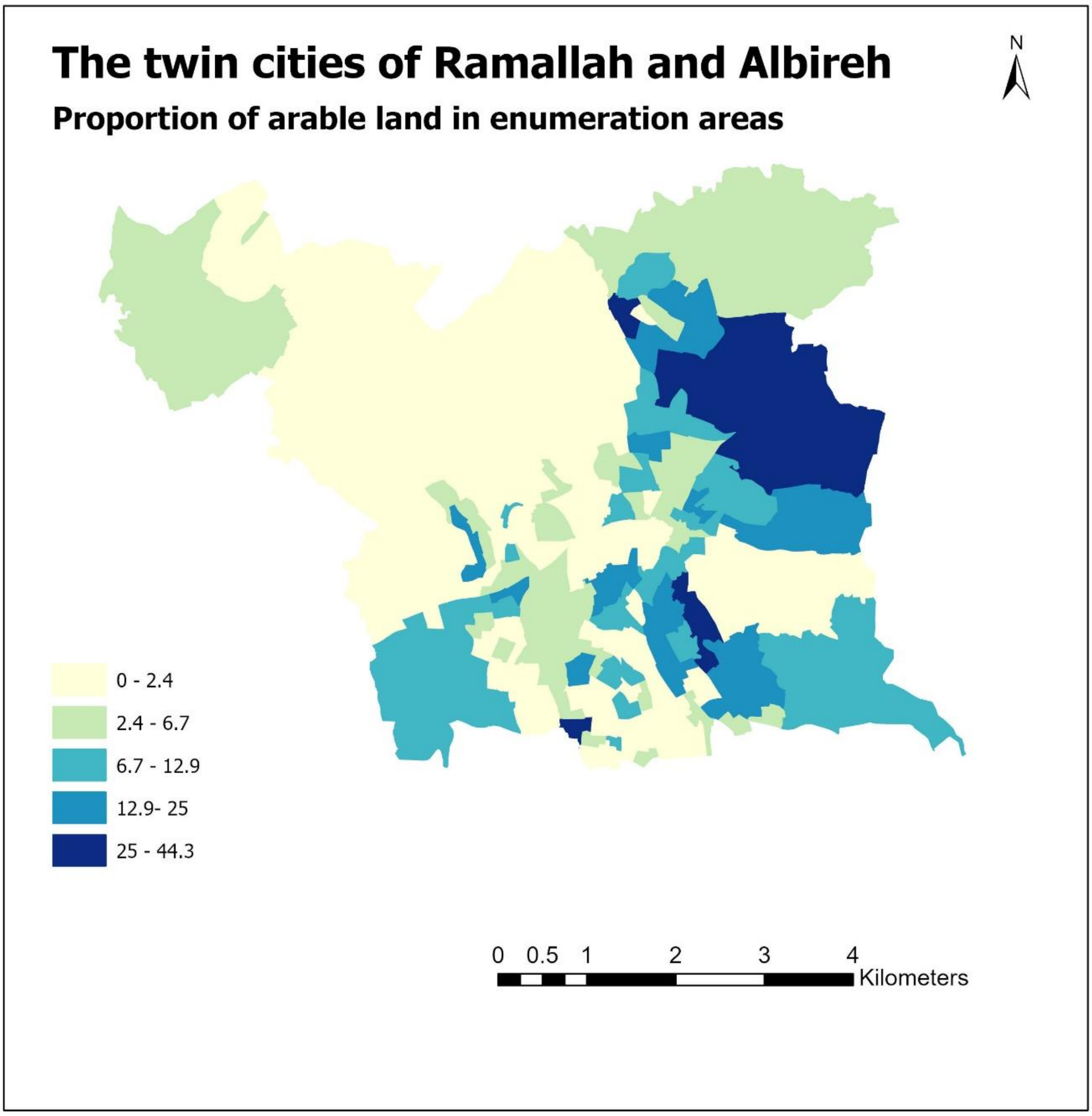

Figure 9-1: Proportion of arable land in the enumeration areas

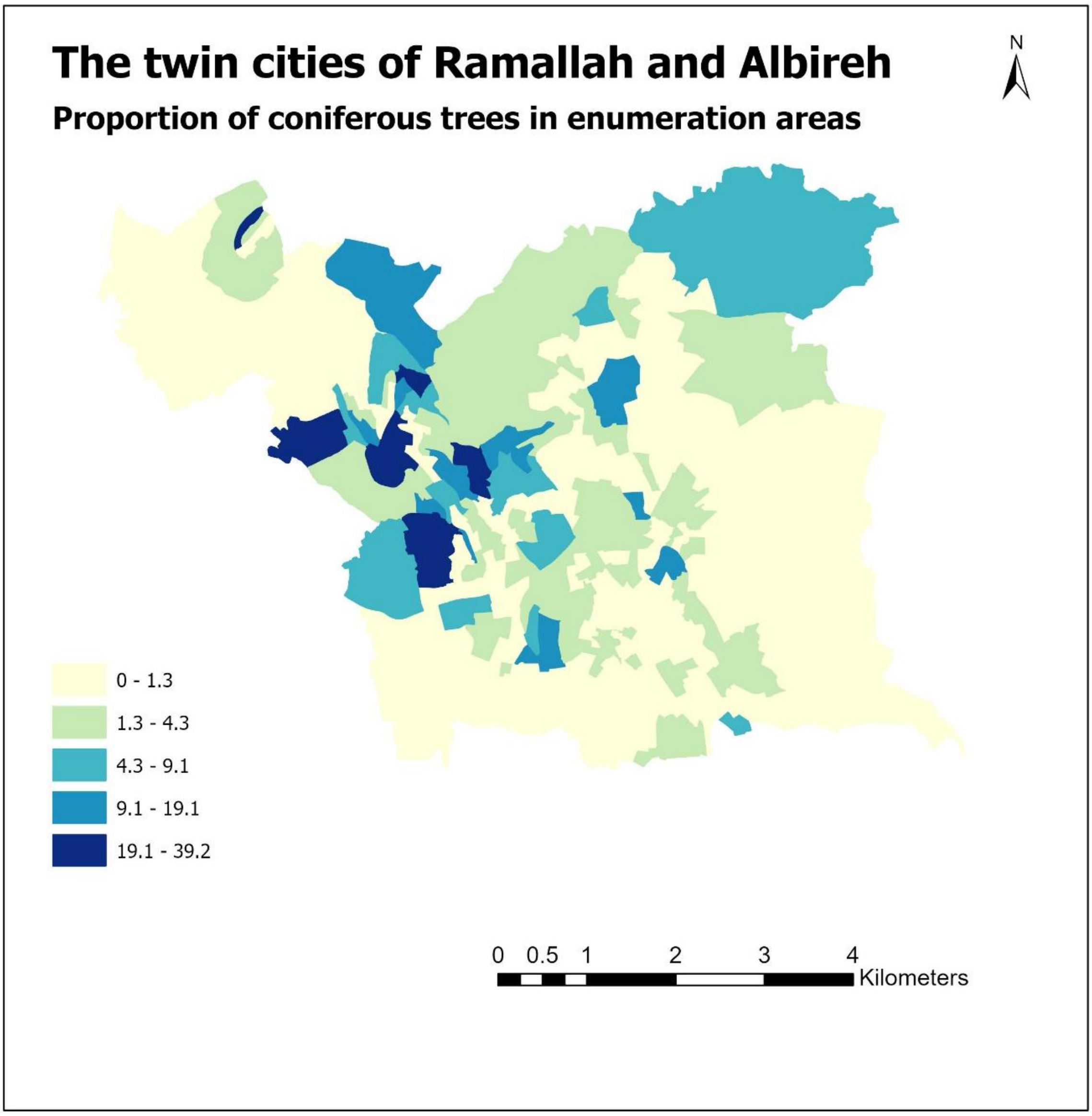

Figure 9-2: Proportion of coniferous trees in the enumeration areas

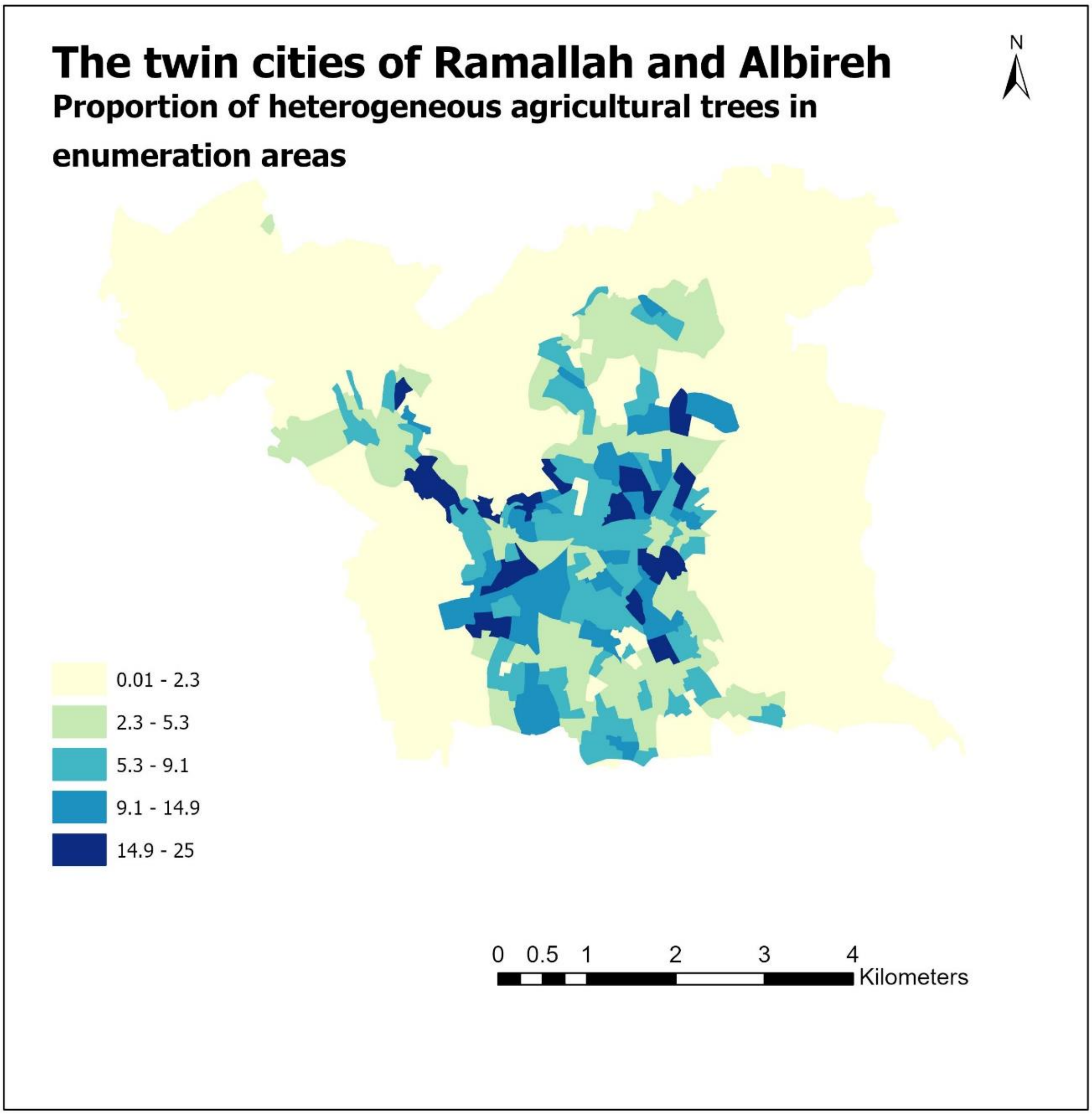

Figure 9-3: Proportion of heterogenous agricultural spaces in the enumeration areas

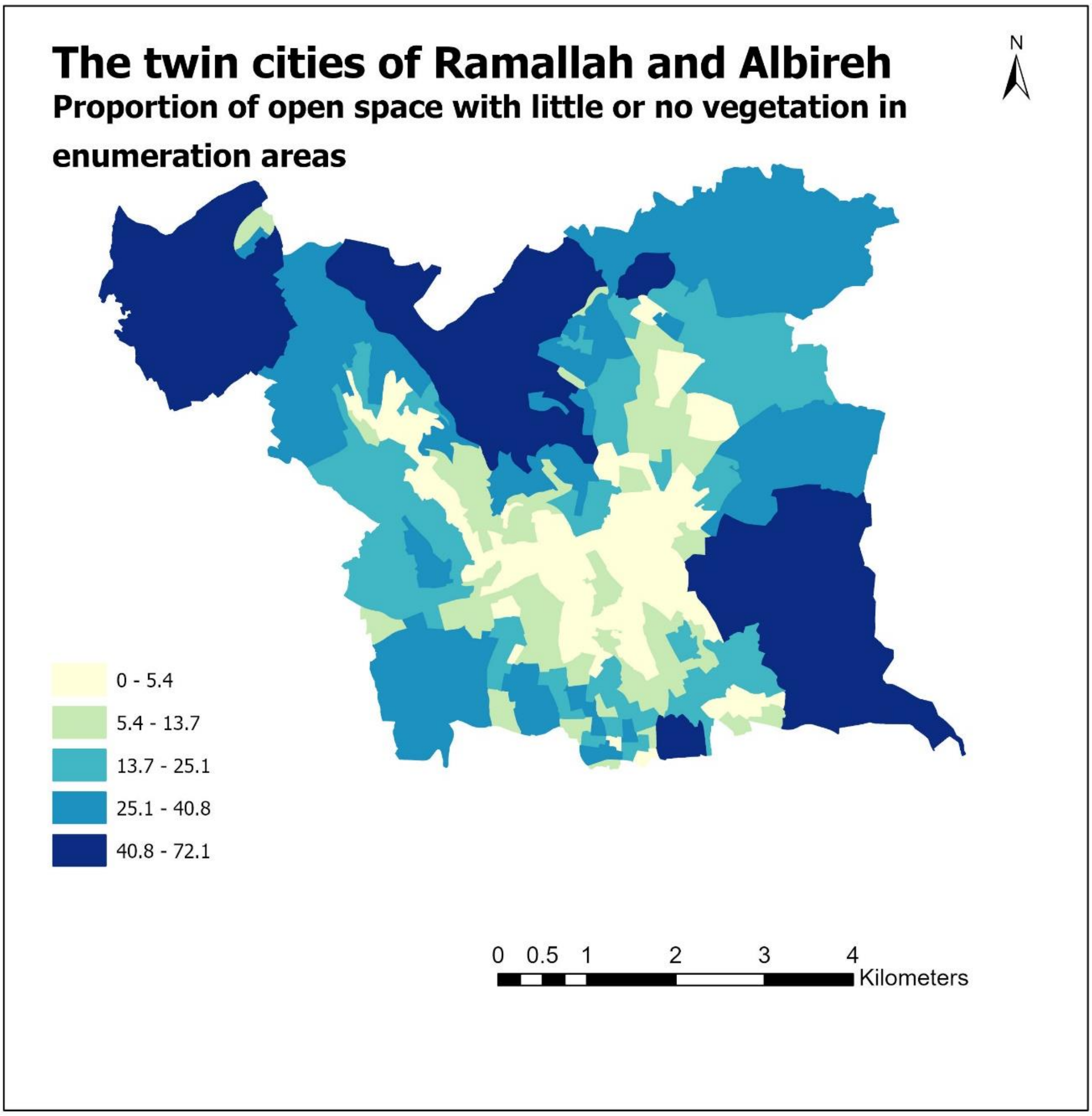

Figure 9-4: Proportion of open space with little or no vegetation in the enumeration areas

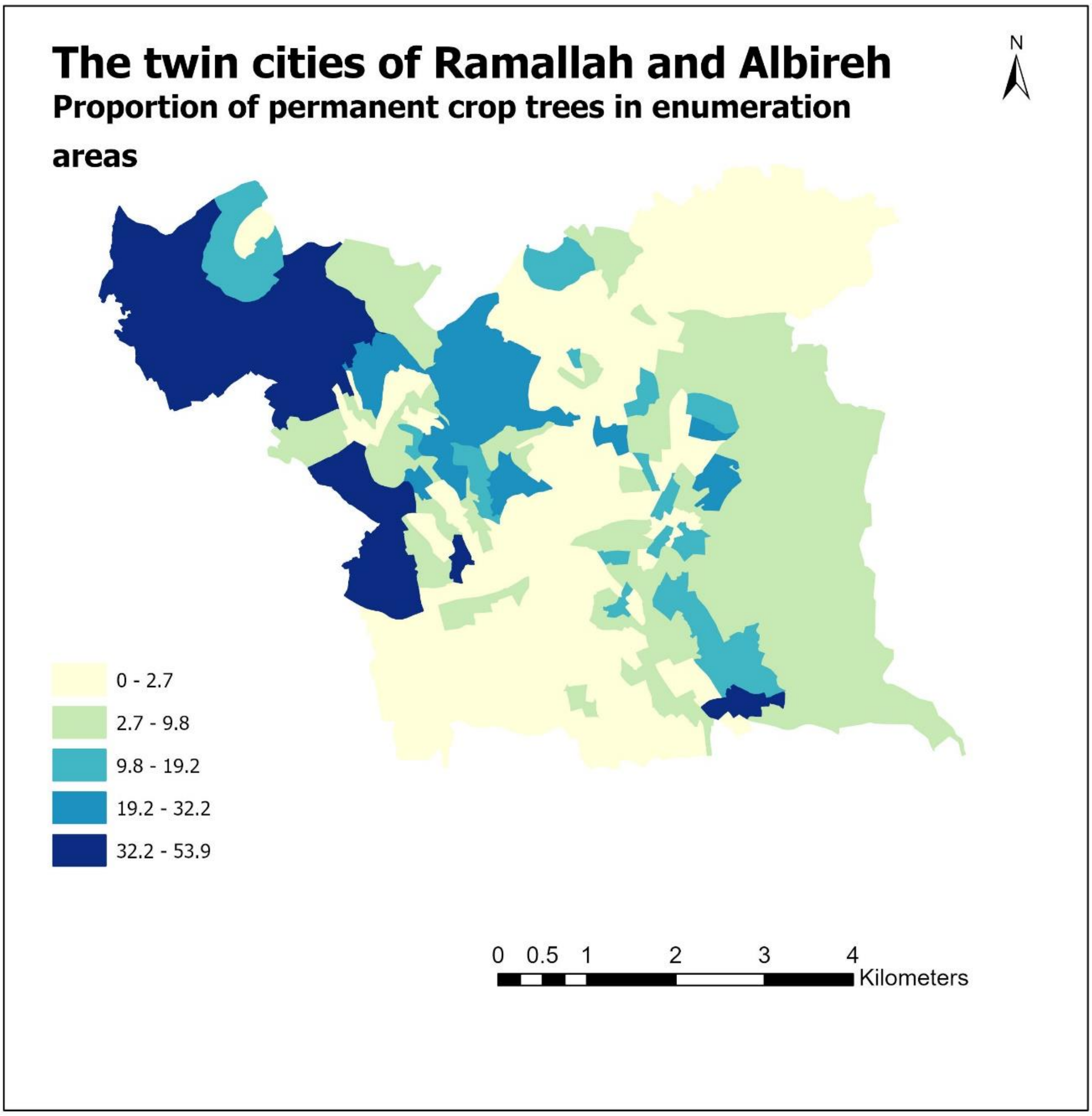

Figure 9-5: Proportion of permanent crops in the enumeration areas

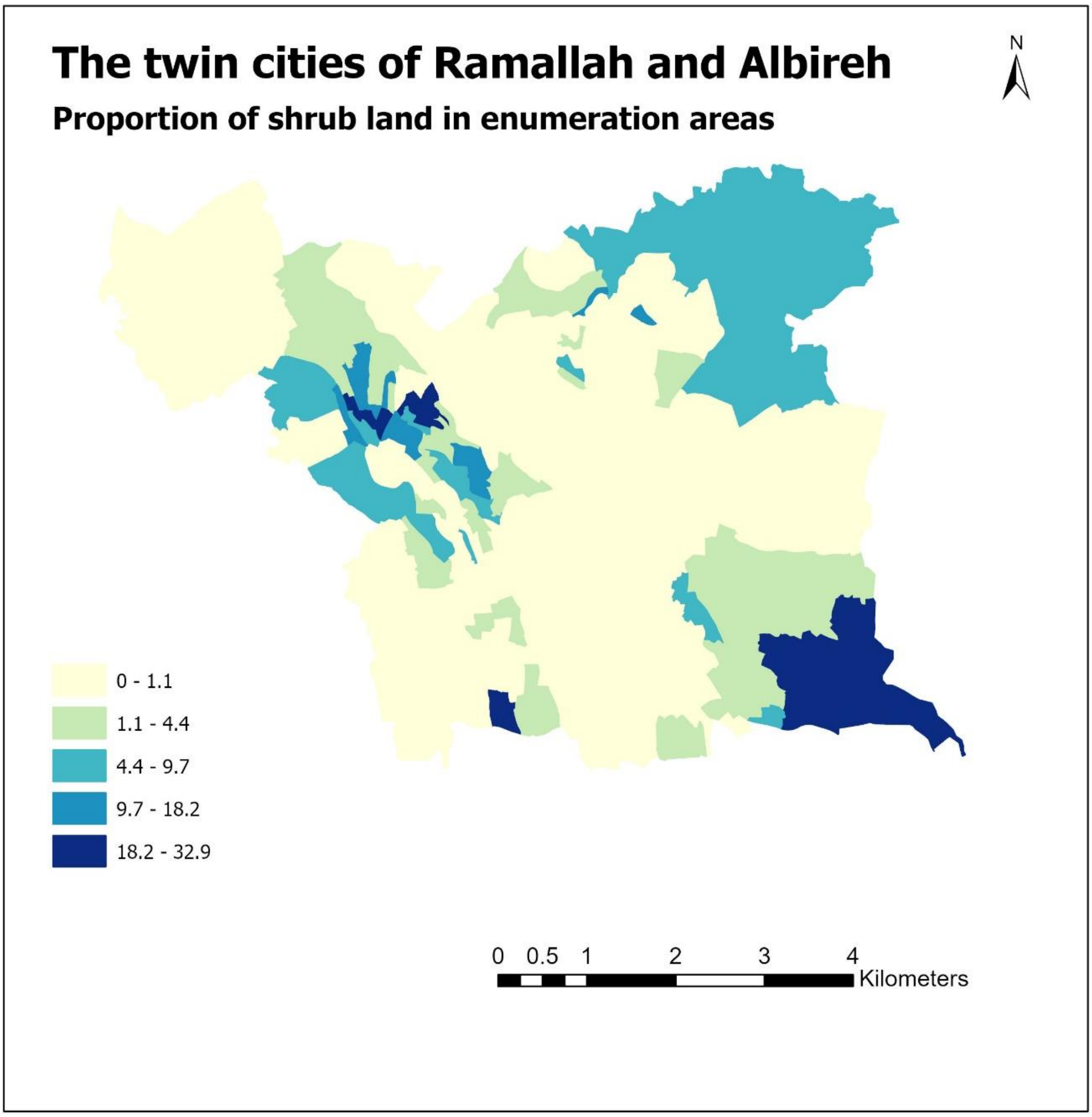

Figure 9-6: Proportion of shrub and/or herbaceous vegetation associations in the enumeration areas

E. Missing values in the final dataset

In this appendix, I will discuss the analysis of the missing values in the final dataset that I used in the regression analysis of this thesis.

Figure 9-7 shows missing values in the 2017 census variables. Age and sex did not have any missing values. Three variables have 993 missing values: chronic illness, health insurance and refugee status. Labour force participation, marital status, and educational attainment have 547 missing values. The rest of the variables had 558 missing values. The number of individuals in the total sample of 55816 with a missing value was 1123, which was 2% of the total sample.

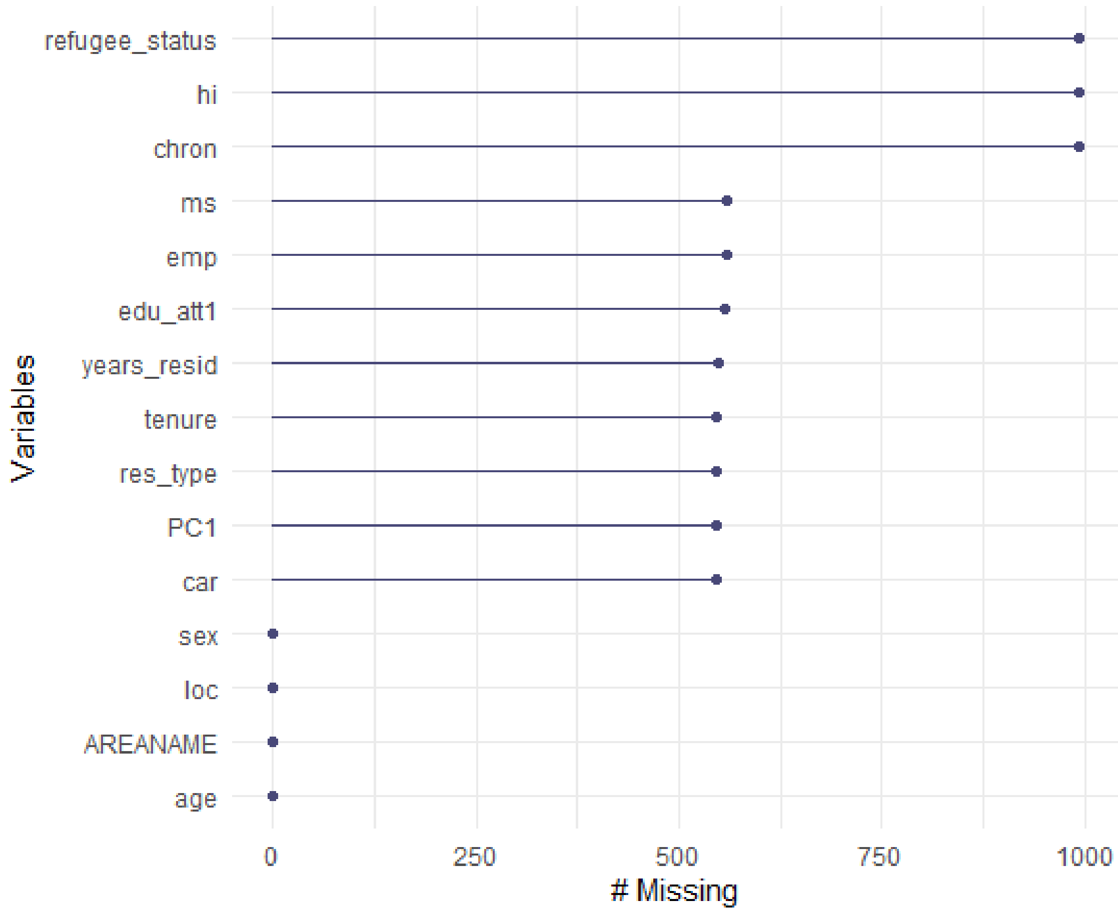

Figure 9-7: The number of missing values in the 2017 census data

I tested the distribution of the missing values across the variables by constructing a missing data matrix shown in Figure 9-8. It shows that grey (missing) and blue (non-missing) box plots do not differ considerably and confirm that the missing values were not remarkably patterned across the variables. There was no significant difference in the distribution of the missing values and the non-missing values across the variables.

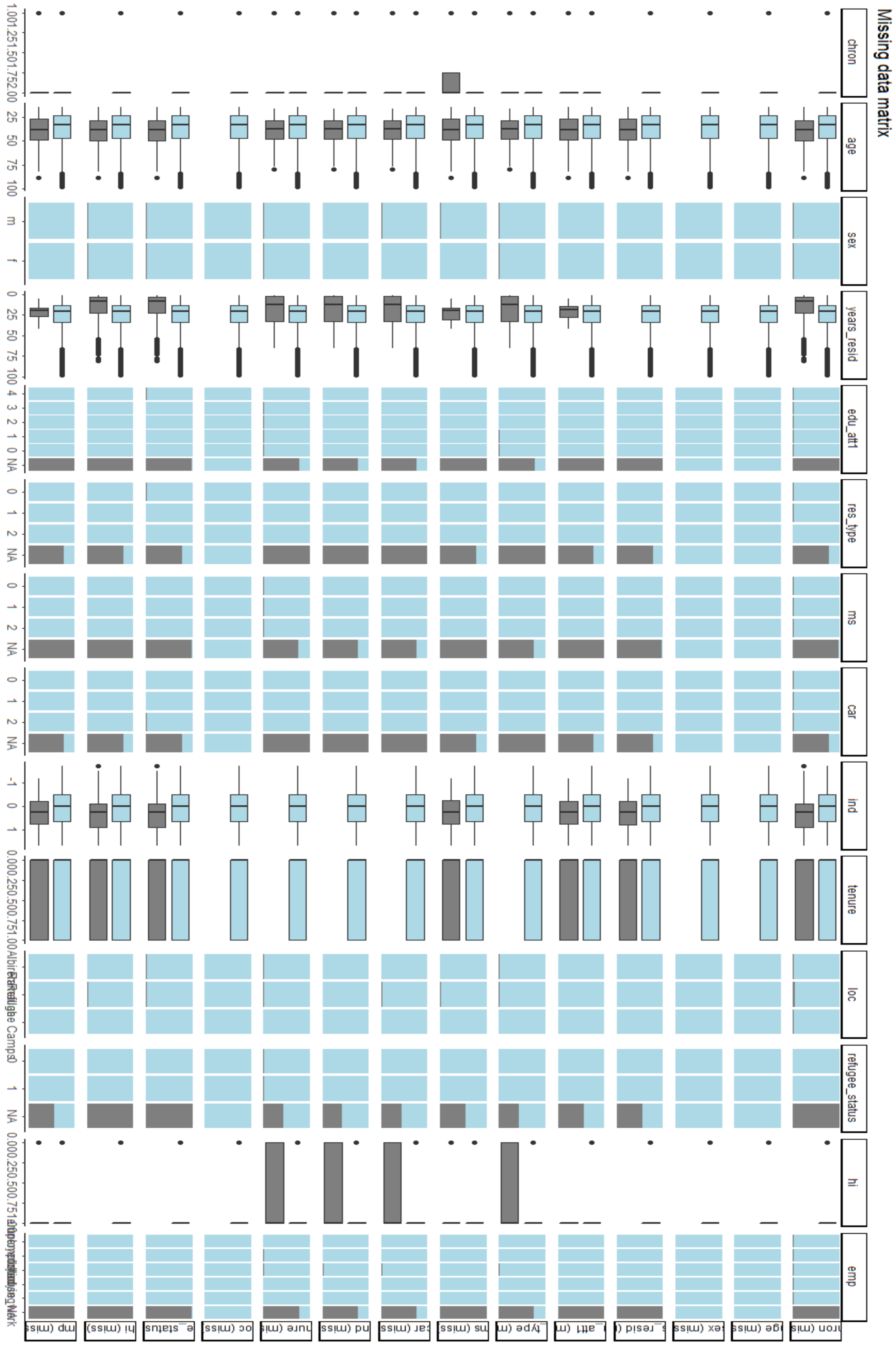

Figure 9-8: Missing data matrix for the 2017 census variables included in the models

F. Final Model simulated residuals

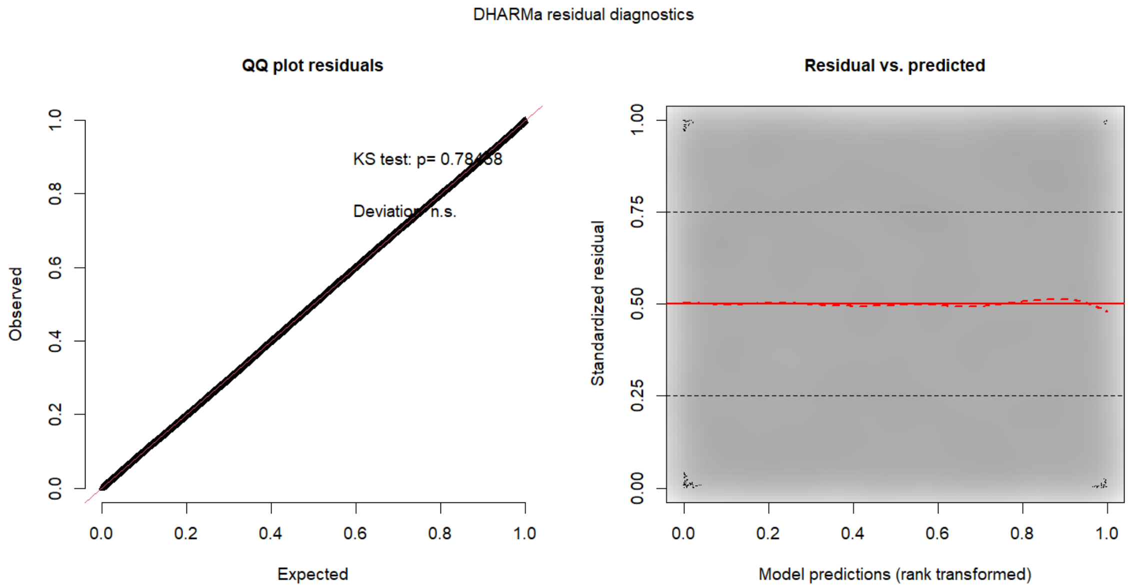

Figure 9-9: DHARMa simulated residuals diagnostics output for the final model

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