Urban Characteristics of Mental Health

Data-driven policy advice for urban mental health strategies

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TUDelft

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by

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to obtain the degree of Master of Science

at the Delft University of Technology,

to be defended publicly on Friday August 23, 2019 at 15:00.

An electronic version of this thesis is available at `http://repository.tudelft.nl/`.

The qualitative files for this thesis are available at
`https://github.com/lisehouwing/Thesis-urbanization-and-mental-health`.

TUDelft

Preface

I have been interested in cities for over a long time. The logistics behind the operation of large cities fascinates me. Moreover, the availability of culture, business, houses and services of a city with such density wonders me. As Takooshian (2013) writes, no animal species live in such large groups as humans in cities nowadays. Being able to establish such large groups is a great achievement of the human. However it made me think. *The logistic and economic advantages of cities are clear, but how does our behaviour get influenced by all those impulses?* This question is what for me brought up the topic urbanization and mental health as a master thesis topic.

Writing this master thesis has been challenging, but very educational. Researching urbanization and health extended both my knowledge and skills. I hope this thesis will contribute to your knowledge, the reader, too.

I would like to thank all my friends, family and fellow students, who supported me during this thesis project. In particular I want to thank my close friends Violetta and Maartje. Going through this thesis process with you made it a lot more pleasant. Furthermore I would like to thank my mother, Jeanine. Thank you for always being there to help me structure my thoughts. Finally I would like to thank my thesis supervisors Scott Cunningham and Haiko van der Voort. Your feedback helped me a lot in drafting the thesis and getting it to the current level.

Lise Houwing
Delft, August 2019

Abstract

The urban population is globally increasing. Additionally, mental health problems are increasing. The determinants of mental health are found to be more present in urban environments. Due to the growing populations and the urban presence of mental health determinants, mental health problems are risking to further increase. This thesis develops a framework, in which the concepts that influence mental health are visualized. Based on this framework, the determinants of mental health are modelled for the case of Rotterdam. Subsequently, the modelling results are translated into the policy system. The findings of this thesis are that the pathways towards mental health are complex, multivariate, interconnected and sometimes contradicting. In order to address this challenge, policy-makers should take an integral evidence-based approach. This thesis conducts a first exploration of the relation between urbanization and mental health. Furthermore, it takes the first step towards developing a policy-process that incorporates this knowledge and is able to act on it. Nevertheless, more research is needed about the urban determinants of mental health, in which data is used on individual level. Moreover, qualitative studies can research integrated evidence-based policy-making in more depth.

Executive summary

This thesis researches the relation between urban characteristics and mental health with the aim to improve mental health strategies for urban policy-making, according to the following research question:

How are mental health problems in urban areas influenced by the characteristics of the urban environment?

The urban population is growing all over the world, along with the mental health disease burden. Risk factors for developing mental health problems are found to be more present in urban environments. Therefore mental health problems are risking to increase simultaneously to the increasing urban population. There are two often used approaches to research the relation between urbanization and mental health. The first approach is defined as research on high level of aggregation. Within this approach relations are investigated by developing frameworks. The second approach is defined as research on low level of aggregation. This research develops univariate or limited variate models to research relations. Both methods do not incorporate the complexity, interconnectedness and contradiction related to the mental health pathways. A holistic approach is needed for evidence-based policy making in order to define effective urban mental health strategies. This thesis argues for research on the middle level of aggregation. Research on middle level should take a holistic approach by including the multiple components involved. Moreover, this research should study those components in depth, using multivariate models.

To investigate the relation between urban characteristics and mental health for policy making an exploratory, deductive approach is taken. In this approach theory is tested on data using the city of Rotterdam as a case. A theoretical framework is developed, visualizing the relation between the individual genetic component, individual resilience, lifestyle, mental health status, economic environment, social environment and the physical environment. This framework is thereafter conceptualized using the open data of Rotterdam. Mental health is measured for the case of Rotterdam by the variables: anxiety disorder, burn out, depression, minimal 1 disorder and not happy. The variables used for the model represent the social environment, physical environment and economic environment. To include the individual component in the model, the population characteristics are also included. Subsequently, variables are reduced using a block-wise approach based on the framework. Negative binomial regression is used for the model estimation. Finally, based on the modelling results the policy arena is analyzed. This is done based on an actor and systems analysis.

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The analysis resulted in the following findings. The first finding is that pathways toward mental health are complex, multivariate, interconnected and sometimes contradicting. Variables of all defined urban concepts are significantly related to the mental health outcomes. This emphasizes the importance for urban policy-makers to develop evidence-based mental health policies. The systems and actor analysis concluded that without interventions the urban system will tend to provide environmental improvements for the better-off, while excluding the vulnerable. This because on one hand the private sector will act based on business opportunities. Since, the better-off have more resources to fulfill their needs, the private sector will develop based on these needs. Therefore, the private sector tends to improve the urban environment based on the needs of the better-off. On the other hand, the better-off are naturally more active in public participation compared to the vulnerable. Evidence-based policy-making should therefore actively include the vulnerable. Moreover, mental health policy should be developed holistic in collaboration with all clusters in municipalities, since the variables from all urban concepts are related to the mental health outcomes.

Furthermore, governments and organizations are currently mainly focused on improving mental health by education and improving mental health care. This thesis shows there is an opportunity to improve mental health by reducing the environmental determinants of mental health. However, responsibilities for these environmental determinants are often fragmented. An integral approach to address the urban determinants should be taken. Advised is to fist initiate an integral approach for defining the environmental determinants of mental health. Subsequently, informed decisions can be made by policy-makers to integrate additional actors. This in order to participate an inclusive set of stakeholders in the policy-making process. In this way policy-makers can set priorities and select solution directions.

This thesis conducted a first exploration of the relation between urbanization and mental health. It emphasized the importance to adopt an inclusive evidence-based approach to urban mental health policies. Further research should be done in defining relations between urbanization and mental health, using larger data-sets both for the amount of cases as for the amount of variables. Besides, next to Rotterdam other cities should be researched to generalize the results. Finally, the last chapters of this thesis give a general description about the policy process. Future qualitative research could be done to evaluate the system and actor analysis.

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Introduction

This first chapter introduces *"Urban characteristics and mental health: Data-driven policy advice for mental health strategies"*. The first section presents the problem statement (1.1). Next, the link between this research and the MSc Engineering and Policy Analysis will be described (1.2). The research gap and main research question will be discussed in the third section (1.3). Followed by, the general approach to research urban characteristics and mental health and the sub-questions (1.4). This introduction ends with a reader guidance (1.5).

1.1. Problem statement

The global burden of mental health problems is growing (Vigo, Thornicroft, & Atum, 2016). The share of global population living in urban areas is increasing simultaneously (OECD, 2015) and determinants of mental health problems are found to be more present in urban environments (Forti et al., 2014; Srinivasan, O'Fallon, & Dearry, 2003). Therefore, in the future a larger share of the global population will be effected by the urban determinants of mental health. This combination may increase the burden of mental health problems. This calls for an intervention by policy-makers, with the aim to reduce determinants of mental health in urban areas and thereby create healthy cities. However, urban challenges involve multiple actors and factors, making the finding of consensus complex, along with the prediction of the made policies (Peris Blanes, 2008). This applies especially when relationships between the environment and the outcome are still unclear, which is the case for the environmental determinants of mental heath.

Problem statement:

Risk factors for developing mental health problems are found to be more present in urban environments. Through the growing urban population, mental health problems are in danger to increase simultaneously.

1.2. Engineering and Policy Analysis master thesis

This thesis is written to obtain the master degree of Engineering and Policy Analysis (EPA) at Delft University of Technology. EPA research distinguishes itself by focusing on grand societal challenges. In this, EPA contributes by approaching the challenges from both the socio-economic and the political environment. For analyzing these challenges, EPA applies among others systems and multi-actor theory. Both urbanization challenges and mental health challenges are considered to be societal grand challenges. First because, as discussed above, they are both affecting a growing share of the population. Besides, the fact that urbanization has the potential to improve the well-being of individuals, it also has brought environmental, economic and social challenges such as air pollution, lack of affordable housing and social exclusion (OECD, 2018).These urban problems are often interconnected and lack optimal solutions. Mental health problems are the result of the combination of genetic vulnerability, human behaviour and poor environmental stresses (Zandi, Wilcox, Dong, Chon, & Maher, 2012) This makes not only the cause of mental health problems complex, but also the solution. On to of this, mental health is included in the Sustainable Development Agenda (World Health Organization, 2017). This research aims to contribute to improvements in urban mental health. This by, analyzing the urban determinants of mental health from a holistic system approach, in which social-economic environments, physical environments and the individual lifestyle is included. The outcomes of the investigation of urban determinants for mental health are translated to policy-making. For linking the urban determinants of mental health to urban policy-making, a multi-actor and systems approach is used.

1.3. Main research question

The topic social determinants of mental health in urban environments has been researched. However, most research investigates the relation between urban concepts and health on low level of aggregation, considering relations between single variables. Despite that this kind of research contributes to a clearer understanding of urbanization and (mental) health, the information for policy-makers is scattered around and connections are missing. On the other hand, health and governments institutes develop frameworks to define the relation between environmental concepts and health and improve healthy policy-making. Though, those frameworks are often generic, they do not provide policy-makers with the dilemmas of healthy policy-making and are often disconnected to the research on lower levels. The result is a gap between the policy frameworks and the low aggregated research. To fill this gap

research should be done that provide policymakers with the depth of the lower aggregated, while incorporating the system approach and interconnectedness of the higher level generic frameworks. This will be implemented by exploring and interconnecting different variables, urban concepts and mental health by answering the research question presented below.

Main research question:
How are mental health problems in urban areas influenced by the characteristics of the urban environment?

1.4. Sub-questions

The relation between urban characteristics and mental health will be researched by using an exploratory deductive approach. This, because the relation between urban characteristics and mental health is still unclear. In addition, a mixed methods approach will be used, in which the low aggregation research is summarized in a theoretical framework, that will be tested by using a case study. Besides, the aim to research urbanization and mental health on a middle level of aggregation is to incorporate complexity, rather than simplifying. For the data analysis the case of Rotterdam will be used, in which a holistic approach will be taken.

During the theoretic analysis the urban environment is separated into three concepts. These concepts are the physical environment, social environment and economic environment. In this theoretical framework, mental health outcomes are defined to be the result from these urban concepts, individual-lifestyle, genetics and resilience.

In this process the following research questions will be answered:

Sub questions:
SQ1: What is the relation of the physical, social and economic environment and lifestyle with mental health?
SQ2: How do the urban environmental characteristics combined, relate to mental health?
SQ3: What are the challenges for urban policy-makers in developing urban mental health strategies?
SQ4: How can evidence based policy making add value to urban mental health strategies?

1.5. Reader guidance

The second chapter of this thesis will elaborate on the importance of researching urbanization and mental health (Chapter 2). This chapter has the aim to introduce the reader to the main concepts or themes used in this thesis: Urbanization, Urban governance and Mental health and their current trends in society. Besides, it will explain how this thesis will contribute to the academic and policy making field based on the research gap.

The third chapter has the aim to develop a theoretical framework, which forms the basis for the analysis (Chapter 3). This will be done by introducing the reader with the three urban environments and the role of the individual in this.

After the framework is introduced the methods will be discussed used for the analysis (Chapter 4). This chapter will first introduce how the research is approached and will subsequently discuss the specific methods that are used for the analysis.

The next chapter discusses the actual analysis (Chapter 5). The first section of the analysis describes the scope of the case study. The second section describes how the theoretical framework is represented by the case. Additionally, it will discuss the limitations of this representation. Finally, the general methods introduced in the last paragraph of Chapter 4, will be translated into the implementation. This last paragraph will describe the modelling process in detail.

The next chapter will discuss the results of the analysis (Chapter 6). The first section of this chapter will discuss the output of the analysis. It will also elaborate shortly on the interpretation of the output, further interpretation can be found in the discussion. The second paragraph discusses the validation of the model. It will validate the model both internal as external. Also here, short interpretation can be found in this chapter. A more extended discussion of the results can be read in the discussion chapter.

The main audience targeted with this thesis are the policy-makers. In order to give good recommendation the results have to be placed in the political arena. This will be done in the following chapter (Chapter 7). This chapter will describe the responsibilities of the municipalities in public health. Besides, it will discuss the latest public mental health trends. Based on the trend analysis a means-ends analysis is conducted. The next section in this chapter will discuss how the actors relate to evidence-based policy-making and the means-ends analysis. The last section will connect the results of the previous sections in this chapter, in order to give a conclusion about evidence-based policy-making.

In chapter 8, the integrated evidence-based policy-making is analyzed in more depth. Chapter 8 will discuss how policy making can benefit from integral and evidence approaches. Furthermore, it describes the risk and implementations of integral evidence-based policy-making.

The next chapter in this thesis is the discussion (Chapter 9). The will first elaborate on the sub-questions and main research question. After this the chapter will discuss and interpreted all results from all the previous chapters.

The last chapter is the conclusion (Chapter 10). This chapter will give a final conclusion based on the research questions.

2

Importance of researching urbanization and mental health

"Health as the pulse of the new urban agenda" (WHO, 2016)

In 2016 the WHO published a report with the following title: *"Health as the pulse of the new urban agenda"*. In this report, the WHO emphasizes the relation between urbanization and health to be complex and interconnected. All policies should be assessed from a health perspective and developed across sectoral boundaries (WHO, 2016). With this report, a new approach to urban policy-making and health was initiated. In this new approach, health should be considered in the policy-making of all sectors within a city. These sectors include the more obvious, such as building a new highway, but also include the less obvious such as building a new shopping centre or giving a permit for a music festival. Furthermore, policy-making should include collaboration between all those sectors and health. This across sector approach to health will impose dilemmas and contradictions to policymakers. One sector can create healthy buffers for another, or small health impacts in different sectors together can lead to significant health inequality deficits. This makes the creation of a healthy city complex. However, policy-makers often lack the understanding of the complexity and interconnectedness of phenomena in cities (Leaf, Ostrow, Manderscheid, Shern, & Eaton, 2012; Srinivasan et al., 2003). Additionally, the relation between physical characteristics of neighbourhoods and health is not clear enough to incorporate health to all policy-making (Evans, 2003). Therefore, the policy maker should be able to have reasonable insight in how the system works and the relation between sectors and heath. This research aims to contribute to this reasonable insight of policy-makers.

This second chapter elaborates on the importance of researching urbanization and mental health research. This is done by first introducing the three main topics of this thesis and their contribution to the problems statement (2.1). After which the second section presents the literature study, including the research gap (2.2).

2.1. Concepts

Gaining a better understanding of the complex relation between urbanization and mental health is becoming increasingly important. This because, the urban population is growing (1.1.1), urban governance is complex (1.1.2) and environmental and social risk factors for developing mental health problems are found to be more present in urban settings (1.1.2). This section introduces those three concepts, with the aim to give the reader the background of the problem statement introduced in the first chapter.

2.1.1. Urbanization

Urbanization is defined as a growing share of the population living in urban areas (Mcgranahan & Satterthwaite, 2014). An urban environment distinguishes itself from a rural environment by having a more heterogeneous population, a greater diversity and availability of facilities and a higher population density (Straatman, 2012). This sub-section describes the urban growth trends and the drivers behind these trend.

Currently, more than 50 percent of the world population is living in cities and this is expected to grow to 85 percent by 2100 (OECD, 2015). Next to population size, cities are becoming increasingly important for the economy. Since 2000 cities contribute up to 60 percentage of the total employment creation and GDP growth (OECD, 2016b). This can be explained by the better productivity and larger labour market of cities. Moreover, cities have the infrastructure to faster spread ideas, and have a more diverse entrepreneurial environment. Cities provide a density in cultural variety, activities and services that rural area's cannot provide (OECD, 2015). On the contrary, cities can also be ground for poverty, inequality, crime, segregation, polarization and environmental degradation (Amis, Preston, & Turner, 2016).

The combination of economic prosperity and cultural opportunities is what drives people to move from rural to urban environments. This attraction of people towards urban environments, is likely to remain in the future. The conclusion is drawn based on the following trends. The modern economy is specialized and concentrated in urban environments. The tendency of modern economy towards a more highly specialized activities, led to the creation of industry centers in cities that attract specialized workforce. Those, more production intensive activities, led to the creation of additional wealth, not only to the industrial centers, but to the employees themselves. On the other hand, the automation and increasing efficiency in the agriculture sector resulted in loss of job opportunities and pushes people to search for economic opportunities in urban environments (Figure 1.1) (Boyd, n.d.). Expected is that economies will remain specialized and concentrated, while agriculture remains to be automated, resulting in a continuing pull towards cities.
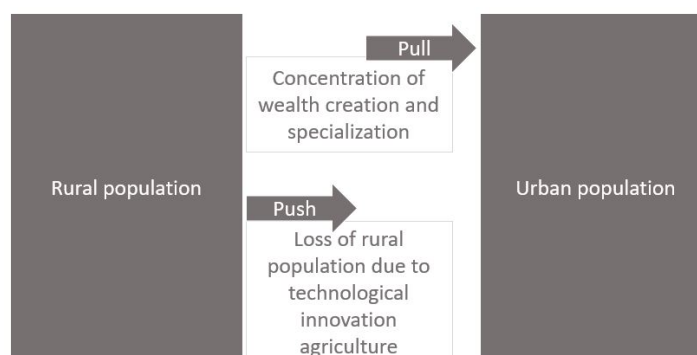
Figure 2.1: Urban growth from an economical perspective

2.1.2. Urban governance

Urban governance is defined as *"the process by which governments (local, regional and national) and stakeholders collectively decide how to plan, finance and manage urban areas"* (Amis et al., 2016, p.1). This process consists of constant negotiation of different values and perspectives. Urban governance should contribute to developing environments which are attractive to live in and work and give the opportunity for citizens to perform duties and exercise rights (*Good Urban Governance*, n.d.). Within governance, mental health policy can be defined as *'the actions and means a society adopts to organize itself for promoting the health of the population'* (Fehr et al., 2017). This section will first introduce the general system of urban governance, after which introduces the complexity of urban governance and the connection to urban growth (2.1.1).

The governance in cities depends on the national governments, the resources of the municipalities, the private sector and the public creating together a certain urban setting (Figure 1.2). What happens in a city is influenced by national governments. National governments provide links between the cities, regions and country to align their developments. Municipalities have the obligation to among others coordinate physical and socio-economic planning processes sufficiently, to shape or create urban settings. For this, municipalities need the skills, capacity and resources to do so. The private sector also has a considerable amount of influence on the urban setting, such as in economic development, design and the available services in the city. The urban governance is is influenced by the public by the public through public participation (Amis et al., 2016). This influence of the public in urban policy making and planning is currently widely accepted as a way to improve the quality of urban life (Badach & Dymnicka, 2017).
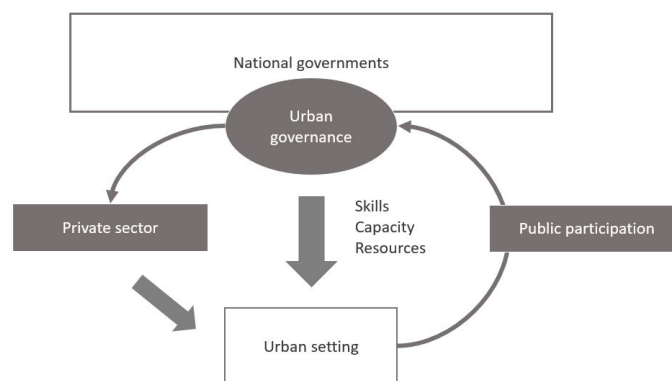
Figure 2.2: Urban governance

Urban challenges involve multi-actors and -factors. This makes negotiations difficult and outcomes of certain policies hard to predict. Dealing with urban challenges require an approach among diverse stakeholders that recognize the complexity of those challenges. Important in urban policy-making is public participation that gives voices to the poor and vulnerable. Urban governance reflects this complex and conflicting process of collaboration between different actors towards comprehensive solutions (Fehr et al., 2017; Peris Blanes, 2008). Good governance include on one hand giving room to conflicting and diverse interests and visions, but on the other hand finding common ground for cooperative action and stimulates participation, civic engagement, inclusiveness and transparency (Amis et al., 2016; Badach & Dymnicka, 2017; Pløger, 2004; The Global Campaign on Urban Governance, 2002).

In short, from the perspective of urban policy makers, an urban environment facilitates close connections between different functions, people and activities in limited space. The dynamics of those connections increases the impact of government policies making them more effective, but also more important compared to rural areas (OECD, 2015). On the other hand this diversity and density of cities makes policy development complex and optimal solutions to problems are often absent. Good governance is more important in urban areas than in rural areas (Mcgranahan & Satterthwaite, 2014). Climate change,

inequality, exclusion, criminality and safety are problems effecting cities all over the world (UN-HABITAT, 2016). Related to health, characteristics of the urban environment such as the pressure of mass marketing, accessibility to unhealthy food and to automation are factors that effects lifestyle of the population and thereby their health (WHO, 2010).

Not only the interaction between the material and the social makes urban behavior hard to study, also the interaction between different points of view such as economic, engineering, geographic, environmental, health and social sciences are complex. On top of this, all those points of views are connected within a city to all different functions, such as housing, tourism and business, and placed in limited space. Urban policy-making will always be a trade-off between different view points and sectors. In general, cities get wealthier as they grow, giving them incentives to grow, but on the other hand increasing problems on the field of among others scarcity of space, logistics and social segregation (Batty, 2013).

2.1.3. Mental health

Mental health is defined as *"a state of well-being in which every individual realizes his or her own potential, can cope with the normal stresses of live, can work productively and fruitfully, and is able to make a contribution to her or his community"* (World Health Organisation, 2014). The term mental disorder describes a large variety of problems, mostly related to thoughts, emotions, behaviour and human relationships, which are perceived to be abnormal (World Health Organization, n.d.-c). This sub-paragraph gives a general introduction to mental health and how the mental well-being of an individual relates to environmental concepts.

The burden of mental health disorders is globally increasing. In 1990, already 21 percent of the diseases were related to mental health disorders (Eaton et al., 2012). In 2016, the burden of mental health disorders was estimated to be 32 percent, being the disease with the highest burden by far (Vigo et al., 2016). The WHO identifies five categories of mental health disorders: depression, bipolar effective disorder, schizophrenia and other psychoses, dementia and developmental disorders (Table 2.1). The burden of mental health disorders does not stop at these mental illnesses. Mental diseases increase the risk for other diseases such as HIV, cardiovascular disease and diabetes (World Health Organization, n.d.-a). This emphasizes government interception to mitigate the individual, social and economic impact of mental diseases.

Table 2.1: Five categories of mental health disorders

Type of disorder	Affected population	Symptoms
Depression	300 million	*"Sadness, loss of interest, loss of pleasure, low self-worth, disturbed sleep, disturbed appetite, tired poor concentration" (WHO, 2018)*
Bipolar affective disorder	60 million	*"Periods of depressive and manic episodes" (WHO, 2018)*
Schizophrenia and other psychoses	23 million	*"Distortions in thinking, perceptions, emotions, language, sense of self, sense of behaviour, hallucinations, delusions" (WHO, 2018)*
Dementia	50 million	*"Affects memory, thinking, orientation, comprehension, calculation, learning capacity, language, judgment" (WHO, 2018)*
Developmental disorders, including autism	unknown	*"Impairment or delay related to central nervous system maturation: impaired social behaviour, communication and language, narrow range of interest" (WHO, 2018)*

Pollution, overcrowding, violence and less social support are all factors in the urban environment influencing mental health (Srinivasan et al., 2003). The World Health Organization developed a framework representing the factors leading to mental health problems. According to them, not only individual attributes and behaviour influences people's health, but also the environment and social-economic status play a major role (World Health Organisation, 2012). These factors are called the social determinants of health (M. R. Bass & Sahu, 2017), defined as *"the conditions in which people are born, grow, live, work and age"* (World Health Organisation, 2018). These social determinants of health, are found to have a large impact on premature death (Schroeder, 2007). This emphasizes the importance of seeing the environment and particularly the urban environment as an opportunity to create health, and as a space for people to be healthy or heal.

Moreover, inequality is often mentioned as one of the key drivers behind social determinants of health. Inequality is considered as a major problem in cities. Without government action, cities are threaten to become "inequality traps" (OECD, 2016a). Equality as an important determinant, is recognized the mental health (World Health Organisation, 2018). In all OECD countries, except in Canada, average inequality is higher in cities compared to the national average in inequality. To counter this trend governments should invest in education for disadvantaged groups, transportation and mixed-income neighbourhoods. Besides inequality, other characteristics of the environment are found to have impact on mental health. These characteristics are among others, noise, crowding, spatial hierarchy, distance and nature elements (Evans, 2003).

2.2. Literature review

The introduction of this chapter introduced the new urban agenda for urban policy making, as presented by WHO. This new urban agenda suggests a cross sectoral approach, in which health is assessed in all policy-making. In order to assess health in a holistic manner, urban planners should have some basic understanding about the determinants of health. This literature review analyzes scientific evidence and evaluates how this evidence fit to the needs of policy-makers. To develop a basic understanding among policy-makers, knowledge should be produced and transferred. This section describes existing research from a broader perspective than urbanization and mental health, in order to get an understanding of the position of urban policy-making in the health sector in general. Literature in this chapter is found by using the Scopus database Google Scholar, Elsevier and the International Journal of Environmental Research and Public Health, searching mainly on the combination of words: urbanization, built environment, health, mental health, health geography, risk factors for mental illness and evidence-based policy-making.

This literature review first elaborates on the history of studying spacial epidemiology and mental health and the (technological) developments (2.2.1). The second section introduces evidence-based policy-making, to introduce the reader to the link between scientific evidence and policy-making (2.2.2. The next section introduces the connection between knowledge from research and policy-making: evidence-based policy-making (2.2.3). Subsequently, research on urbanization and health will be presented on different levels of aggregation. The next subsection presents the urban frameworks on height level of aggregation (3.2.4), after which the univariate modelling on lower level of aggregation is discussed (2.2.5). This has the purpose to identify the "missing" middle level relevant for urbanization and health, which is defined as the research gap (2.2.6).

2.2.1. History of spacial epidemiology and mental health

Before the 1980, health research was mainly focused on acute diseases and population trends. The main reason for this was, that this relation is technically more easy to describe, compared to the epidemiology of mental disorders (Eaton et al., 2012). From 1980 onward, researches started to study the geographical or spacial aspects of health (Jones, 2017; McLaughlin, 2017; Philo & Wolch, 2001). Spacial aspects play an essential role in creating a better understanding between the interplay of different characteristics of the urban environment and health. The combination of health and geography deals with how people and the environment interact and it represents society and space by defining the role of the role of place in human health (Dummer, 2008; Mayer, 2000). Health geography is a research field going on since the 1970s, but the progress of this field has been slow, and health geography is underused for its potential (Roux & Mair, 2010). This, because researchers started to realize that health in general cannot be explained looking only at the individual level. Moreover, researches started to realize the impact of inequality on health and the complex relation between urban policy making and health. Many policies affect health, regardless of their field. Finally, the methodologies to deal with large data-sets and geospatial data such as Geographic Information Systems (GIS), makes it more a accessible to study those topics (Roux & Mair, 2010). However, the backlog in the research areas mental health epidemiology and health geography still shows in published public health research. Research still focuses mainly on either developing theoretical frameworks or describing univariate relations.

2.2.2. Introducing evidence-based policy-making

The process of developing policies based on scientific knowledge is known as evidence-based policy-making. Evidence-based policy assumes, that policies become effective when they are based on the latest knowledge (Namdarian, 2015). Policies should be objective and the result of rational analysis, instead of ideology or whims (Richards, 2017). To reach this, public policy should be guided by scientific evidence (De Marchi, Lucertini, & Tsoukiàs, 2016). Additionally, open government data and sensors give the opportunity to learn and monitor

systematically (Hunter, 2015). Evidence-based policy-making started in clinic health in the 1990's. The success of evidence-based policy-making in health made the concept desirable in other sectors such as public health (Bartlett, 2013; Head, 2015).

In order to develop evidence-based policies, the gap between researchers and policy-makers should be closed (Kammen, Savigny, Sewankambo, & Hague, 2006). Researchers should have a good understanding about the policy-making process, while policy-makers should get more involved in conceptualization of research and should be able to interpreted the research (Bédard & Ouimet, 2016). Closing this gap in collaboration of policy-makers and researchers is also known as "Knowledge brokering" (Kammen et al., 2006). "Knowledge brokering" does not focus on the transfer of results from research to policy-makers, it focuses on organizing an interactive process between the researchers and the policy makers (Kammen et al., 2006). To reduce technocratic and hegemonic risks, the public needs to be involved. Evidence-based policy-making in which knowledge is brokered by co-creation across interfaces leads to more inclusive and transparent decision-making (Martinuzzi & Sedlacko, 2016).

2.2.3. Relating urbanization to (mental) health on high level of aggregation

One of the earliest models of urban psychology is the model of urban overload from Stanley Milgram. This model conceptualizes cities to have more impulses than people can process. This overload of impulses or stressors change the behaviour of people, and their ability to connect to others (Blass, 2013). According to this model, the difference in stressors between urban and rural environments explains why people act different in different environments. This change in behaviour could impact health.

Over time, several frameworks have been developed to describe the relation between the environment and the well being of humans (Leidelmeijer & Kamp, 2003; van Kamp, Leidelmeijer, Marsman, & de Hollander, 2003). This environment can be described as the interaction between the biological and the physical environment, facilitating among others the social and economic environments (Institute of Medicine, 2001). Leidelmeijer and Kamp (2003) conducted a study in which several theoretical frameworks are described and compared. A selection of those frameworks relevant to mental health are described in the appendix (Appendix A). Those frameworks communicate interesting and important dynamics between different environments. In this, the environment is often "disguised" in concepts related to two or more of the components: physical environment, social environment and economic environment. These combinations of urban concepts is subsequently connected to outcomes such as quality of life, livability and health. These frameworks are relevant to policy-makers, because they summarize the environmental system towards these outcomes. Policy-makers can "quickly" get a basic understanding of those systems. However, they do not represent any measurable variables, which makes the frameworks not directly operational and makes it hard for policy-makers to get an understanding of the dilemmas policy-making bring.

The framework of Leidelmeijer and Kamp (2003) does present measurable variables. It connects the high aggregated theory with low aggregated variables. It gives urban policy-makers the opportunity to measure the performance of those variables in the environment. However, the variables presented within this framework are selected based on a literature study. The relationships between variables and outcome are not modeled and therefore relations are still unclear. The framework does not distinguish variables in important and less important, which makes it hard for policy-makers to set priorities. Moreover, it does not communicate the interconnectedness of the variables and the contradiction this interconnectedness brings, which results in dilemmas for policy-makers.

2.2.4. Relating urbanization to (mental) health on low level of aggregation

Next to the high aggregated frameworks, a lot of research has been done on low aggregation. Research on this level focuses on defining relations between specific variables. This, in order to investigate the impact of the built environment on mental and physical health, in for example physical activity places (Spoon et al., 2015). A large amount of research has been done investigating the impact of green or nature. Those studies investigates the impact of nature on stress reduction (Beil & Hanes, 2013), on perceived health (Maas, Verheij, Groenewegen, De Vries, & Spreeuwenberg, 2006), symptoms of depression and mental health in general (Lane et al., 2019; Vanaken & Danckaerts, 2018) and whether the mental health vulnerable population groups benefit more from green than others (Ruijsbroek et al., 2017). Even the visibility of urban greenness in high rising buildings would positive impact on people's well being (Olszewska-Guizzo, Escoffier, Chan, & Yok, 2018). Another study researching the impact of the built environment on mental health, had focus more on the economic side. This study found a correlation between the lack of access to a car or van, living in rented accommodation and houses with ´structural´ problems, such as cracks in the wall, with depression (Weich et al., 2002).

2.2.5. Research gap: interconnecting different urban concepts to mental health

As mentioned in the second paragraph in this chapter, there is a need for researching urbanization and health for urban planning purposes. Although, conceptual frameworks give urban planners and policy makers a general idea about how different urban concepts influence health, they do not provide information about which characteristics of these urban concepts influences health and the strength of these relations. On the other hand, the low aggregated research can provide urban planners and policy makers with the knowledge of relations between specific characteristics in more depth, but it does not provide the urban planners and policy makers with the overview needed to consider dilemmas and make decisions. Furthermore, policy-makers have rarely time to assess all this kind of fragmented scientific research (Bartlett, 2013). Moreover, the two approaches for clarifying the relation between urbanization and health does not always consider geographic location. For urban planning and identifying environmental health risks in the

urban environment, location plays a big role (Dummer, 2008).

To conclude the relation between the urbanization and mental health has been researched by using different scopes and variables. On high aggregation the (urban) environment and health is researched by means of conceptual frameworks. On lower aggregation the relations between specific environment characteristics and mental health are researched. This presents a research gap on the middle level of aggregation. Health geography is one method through which urbanization and health can be researched on this middle level of aggregation. Where urban planners might lack direct relations between components in conceptual models, and information about these relations is scattered through papers in the low aggregated research, health geography presents a way to research and communicate relations between different environment characteristics and mental health and their connection with urban space. Through the methodological development since the 1980´s in dealing with complex data sets and spatial data, the opportunity is now to incorporate space and use a large amount of variables to determine the relation between neighbourhoods and mental health.

3

Towards a theoretical framework

"Humans have limited capacity for processing information, ... a surfeit of such information, ... in part created much of the malaise of current living" (Blass, 2013)(p.17)

It has been only 0.4 percent of human history, that humans live in large cities. The term city did not exists until 5,000 years ago, and even then it represented only a few tiny urban settlements. It has been from 1800 on-wards, that cities began to rise to modern standards, as the result of technological revolutions. In general, all animal species have their natural size of groups. For humans, this natural group size used to be a few hundred of less. No animal spice forms group sizes close to the big human cities nowadays (Takooshian, 2013). Comparing the size of modern cities to the "natural size" of human settlements, it must be true that humans experience some kind of overload, confirming Stanly Milgrams theory (Blass, 2013). It also must be true that this "overload" results in some kind of change in human behavior, leading to different feelings, values, relationships and habits.

This chapter is written from the assumption that this relation between urban overload an human behaviour exists within cities. The aim of this chapter is to develop a conceptual framework based on theory, which forms the basis for the analysis in the upcoming chapters. The books Public Mental Health edited by William Eaton and Palaces for the people written by Eric Klinenberg are used to establish the general framework of this chapter, complemented with other scientific research. The urban environment in which people live and interact are divided into three sub-environments: the social/cultural environment, the economic environment and the physical environment (2.1) (Institute of Medicine, 2001; Leidelmeijer & Kamp, 2003; Nijkamp et al., 1998; Shafer et al., 2000). All those environments interact with individual's behaviour and how biological characteristics are expressed (2.2). This relation between the urban environment and the individual can be represented in a theoretical framework (2.3).

3.1. Three urban environments

As mentioned in the introduction of this chapter, the interaction between the individual and the urban environment can be divided into three dimensions. This paragraph describes those three dimensions. First the cultural ans social environment will be described (2.1.1). The second dimension is the economic environment (2.1.2). The physical environment is the last urban concept described in this section (2.1.3).

3.1.1. Cultural and social environment

Culture relates to groups of people that have shared values and perceptions. This influences how humans experience environments and behave in environments. It influences people's mental health (Good, 1997). The social and cultural environment influence more, than whether people develop mental health disorders. They also influence the definition of mental health problems. After all, mental illnesses is besides a psychiatric condition a social condition. This, in the sense that the diagnosis is often depend on what is considered to be normal or abnormal behaviour in a society (J. K. Bass, Eaton, Abramowitz, & Satorius, 2012).

Our interaction with people influences behaviour and helps us to shape who we are. Groups and group forming influence the behaviour and feelings of individuals (Sennett, 2018). One important variable representing the social environment is social cohesion. A community with a higher social cohesion is defined to have more shared values, less wealth disparities, more engaged in common enterprises, more sharing and feel more belonging to the community (Easterly, Ritzen, & Woolcock, 2006). In general, social cohesion is lower in urban areas compared to rural areas. Moreover, social cohesion has been found decrease depression prevalence (Zock et al., 2018). Social infrastructure is defined as the physical structure that shapes people's interaction and social capital. It can been seen as a measurement for relationships and social networks(Klinenberg, 2018).

According to Klinenberg (2018) social infrastructure increases social capital. Subsequently, improved social capital improves the mental and physical health of people. This not only because social connections decreases the risk of developing mental disorders, having social support also increases chances of recovering. This recovery is represented by the term recovery capital. Participation in public life is stimulated by social infrastructure such as safe public spaces, such as green spaces, libraries, schools and universities. In cities nowadays neighbourhood gentrification is a growing problem. *"Neighbourhoods become homogeneous and insular, not open and diverse. The social environment grows less hospitable. The architecture becomes forbidding and severe."* (Klinenberg, 2018, p.47). This growing in-group connections increases bonding social capital, but on the other hand decreases bridging social capital and neighbourhood inclusiveness (Klinenberg, 2018; Macleod & Ward, 2002). Bonding capital is about in-group connections in which people live in their own segregated classes. Bridging social capital, are social connections between

people from different classes (Klinenberg, 2018).

3.1.2. Economic environment

The economic environment represents the (economic) resources an individual can access. One variable that describes the economic environment is the socioeconomic status (SES). Socioeconomic status is similar to social cohesion, but focuses mainly on the economic resources of individuals and their hierarchical social status or power (Hackman & Farah, 2009). Where social cohesion mostly describes the relations between individual vertically, social economic status describes these relations horizontally.

Nowadays, the position where people stand in society is becoming personalized and highly influenced by how you have improved yourself in for example work. This effects the urban environment. Neighbourhoods are becoming homogeneous, belonging to the working class only. Gentrification defines this trend, in which the top quarter of the city pushes the rest of the populations out of desirable districts and thereby increases the distance between social classes (Sennett, 2018). These changes have influence on human behaviour and the mental state of an individual. Research shows that social economic status effects mental diseases like schizophrenia, depression, anxiety disorder. However, these results are not always consistent (Martins et al., 2012).

3.1.3. Physical environment

The Physical environment of a city can be seen as a sum of buildings, connected by public space. The Physical environment facilitates the interaction between the individual, the social environment and the economic environment (Vanaken & Danckaerts, 2018). This relation between the material world and social processes, brings complexity from both philosophical as methodological points of view. How to define this relation, when it is a coming together of so many variables and is the result of complex pathways leading to emergent behaviours (Batty, 2013; Hillier & Vaughan, 2007).

The physical, the social and the economic environment together, shapes behaviour of people through life, and therefore effects risk for mental disorders. As a result, the physical environment does not only influence human behavior direct, but also indirect through the economical and social environment (Figure 3.1).
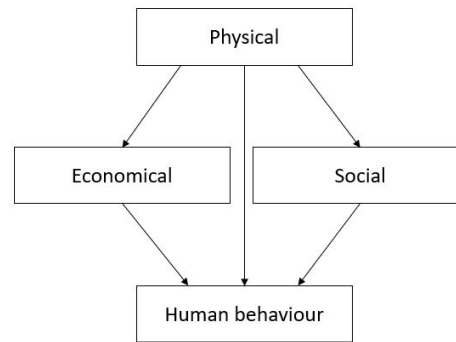
Figure 3.1: Relation physical environment and human behaviour

3.2. Individual biological characteristics

Whether people develop mental illness is an interaction between genes, behaviour and the environment (Figure 3.2) (de Beurs, 2017; Gilissen et al., 2017; Hettema, Prescott, Myers, Neale, & Kendler, 2005; Jaffee & Price, 2007; K. Kendler et al., 2008; K. S. Kendler et al., 1995; Zandi et al., 2012). The following describes the key message of this figure. The genetic material of people can either make them resistant or vulnerable for mental diseases. How people behave, can influence whether people will develop mental health disorders. For example, people can choose to live in an environment with many mental health triggers, or can choose to evade those environments. Moreover, people have influence on how these triggers or stressors are processed. For example, one person can have a demanding job and have next to his or her demanding job, a demanding social life. Another person with exactly the same genetic characteristics, might have exactly the same demanding job, but exercise, take walks through the nature, meditate etc. Where the first person might not have the buffer to process this stressors of the demanding job, person two uses his or her free time to process these stressors. As a result the first person might develop mental health disorders sooner. Furthermore, one might not always have the choice to evade certain mental health triggers. A person might be stuck in an environment, because this person might not be able to afford a home in a better environment. Another option might be, that people do not know that their neighbourhood is decreasing their mental health, or that neighbourhoods all have different mental health triggers. This is summarized by the environmental concept.
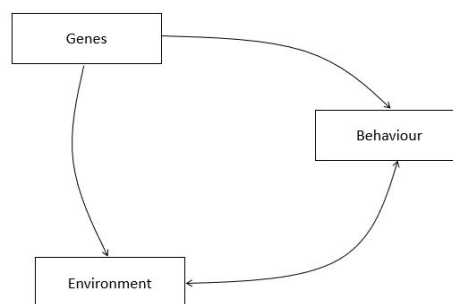
Figure 3.2: Determinants of mental health individual level

The interaction between genes and the environment differs among individuals. However, the mental health outcome explained by the genetic component is difficult to model, because a lot is unclear about role of genes within mental illnesses (Zandi et al., 2012). More is known how the brain interacts with environments. Most of the mental illnesses are the result of chronic brain dysfunction, in this stress often plays a major role. The diathesis-stress model (Figure 3.3) describes the interaction between biological vulnerability and environmental stress (Carlson, Eldreth, Chuang, & Eaton, 2012).
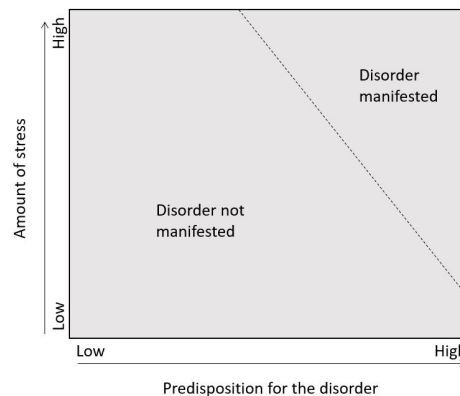
Figure 3.3: Diathesis-stress model

Stress is defined as life events that disrupt the stability of biological and behavioral mechanisms. Stress happens often in three stages: alarm reaction, resistance and exhaustion. The effects of these stages on the body increase risk for both mental and physical disorders. Stress can be divided into developmental stress and situational stress. Where a developmental stressors is the result from normal growth, situational stressors result from unanticipated events that threaten the (emotional) balance of an individual. Stress levels above a persons certain stress threshold, can lead to deregulated stress responses and a reduction in hippocampal volume, which increase risk for several mental disorders. Additionally, stress can negatively affect social relationships, making a person more vulnerable to mental illnesses (Bradshaw et al., 2012).

Environmental factors such as SES can increase stress, but other environmental factors such as greenness can create buffers for stressors. These stressors and buffers combined, determines whether a persons threshold will be reached. This threshold does not has to be stable, it can change through life. "Healthy" amounts of stress over the life course can improve the capability to deal with stress, while severe forms of stress such as traumatic events can decrease this capability. This healthy adaptation of a person to stressful events through life is called resilience. Resilience and it's development trough live, is a complex concept where internal risks interact with external risks (Bradshaw et al., 2012). Crises activates a more extreme form of stress with the fight-or-flight response, associated with several stress disorders (Storr, Azur, Bass, & Wilcox, 2012).

3.3. Theoretical framework

Chapter 2 elaborated on the history of theoretical urban psychology and concluded that recent technical developments provide the opportunity to model the knowledge generated urban psychologists such as Georg Schimmel and Stanly Milgram. The first sections of this chapters described the three dimensions of the environment and the individual characteristics. The next step is to connect these concepts with mental health. This done by first defining human behaviour and the role of mental disorders and lifestyle in this (3.3.1). The theoretical framework is presented in the next paragraph (3.3.2). The third section extend the framework with measurable characteristics as described in literature (3.3.3). The last section describes the role urban policy making in this framework (3.3.4).

3.3.1. Human behaviour: lifestyle and mental health

Stanly Milgram gave the hypotheses of urban overload changing the behaviour of individuals. To incorporate mental well-being in the theoretical framework, the relation with human behaviour must be established first. Human behaviour represents both physical and emotional behaviour. It incorporates thereby as well how we act as how we feel. This research scopes the broad definition of human behaviour down to lifestyle and mental health disorders (Robertson et al., 2015). The First chapter already gave a definition for mental health disorders. Mental health can be seen as a disruption in this emotional end physical behaviour, which is illustrated by the definitions of the five categories of mental health (Table 2.1, Section 2.1.3). Diagnoses for mental health are related to what is considered to be normal and abnormal behaviour (J. K. Bass et al., 2012). Mental health is therefore conceptualized as a form of behaviour in the theoretic framework. Lifestyle is in often used as a concept to explain or categorize patterns in behaviour and health inequalities. Lifestyle in a broad sense, is defined to be the interplay between conditions and behaviour. Lifestyle reflects the free choice an individual can make to adopt healthy or unhealthy behaviour (Contoyannis & Jones, 2004). Therefore, lifestyle is also defined as a form of individual behaviour.

The connection to the other concepts such as physical and social environment are similar for mental health and lifestyle. For visualization clarity the concepts will therefore be visualized as part of behaviour (Figure 3.4). Actual relations between variables can be different for mental health and lifestyle. For modelling the system mental health and lifestyle should be taken separately. Mental health in this framework, is not divided into the categories as presented by the WHO (Table 2.1, Section 2.1.3), this because the difference between the categories and their relation with the environment is unclear.
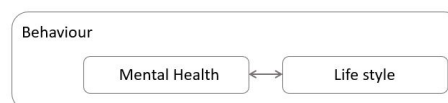
Figure 3.4: Lifestyle and mental health

3.3.2. Relating the concepts in a conceptual framework

The three urban dimensions, behaviour and biological characteristics of an individual are combined into one conceptual framework (Figure 3.5). This figure is explained in the text below.
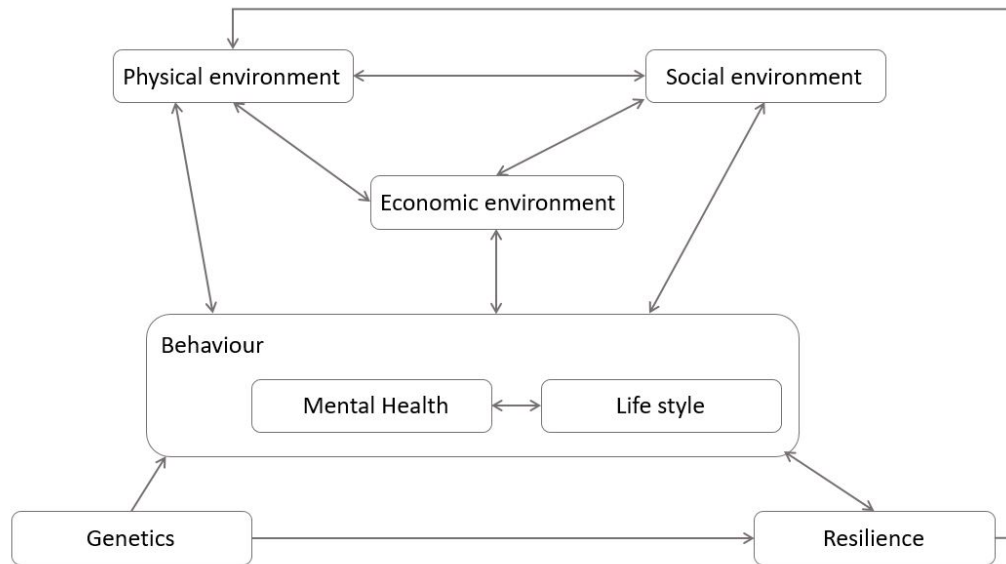
Figure 3.5: General conceptual framework

In this conceptual framework all arrows can be both positive or negative, since they can all increase (perceptions of) stress or create buffers for stressors (Helbich, 2018). The physical environment can become better or worse based on community participation. This because, if the community is engaged with the physical environment, they will be more likely to keep an eye on and engage with the open space. The physical environment is also effected by the economic situation of the individuals living in this environment, as people with a better economic situation have more resources to improve their physical environment. The social environment is influenced by the physical environment. In order to develop social networks, people need a place where they can meet other people. Besides this, the social environment is influenced by the economic situation of a person. Class is an important identity marker, based on which people will tend to connect preferably with their own kind. This applies especially, when taking the growing segregation from nowadays in to account (Klinenberg, 2018). Finally, the social environment is influenced by human behaviour. In the end it is the individual who decides to be open for meeting new people and feels connected to the behaviour of another. The economic situation is influenced by the social environment, especially during the early stages of life, the resources to learn and develop will be different among social classes. Next to the social environment, the behaviour of the individual also influence economic situation, one person will be more driven and ambitious than another.

3.3.3. Extending the framework with urban characteristics

In the previous paragraph a general version of the conceptual framework is introduced. This paragraph continues on this framework, by adding variables influencing these concepts based on mostly low aggregated research, as defined in the literature review (2.2.3) (Figure 3.6). Nature and walkability are variables in the physical environment, that often come up as influencing mental health. Social infrastructure, such as libraries, schools and open spaces are also associated with mental heath. Important for people to actually participate in those facilities, is the safety perception. Finally housing is an important factor in the physical environment for mental health. In the social environment, mental health is influenced by all kinds of social capital, such as bonding capital, bridging capital and recovery capital. Loneliness is associated with these forms of social capital and is found to have impact on mental health. The economic environment can be divided into wealth or power/class. The last concept is resilience. The resilience is of a person against mental health disorders is defined by the brain. The size of the hippo-campus is found to have a relation with several mental health disorder. More often research is the relation between stress or the ability to deal with stress and mental health disorders. The literature that described those variables is included in the table on the next page (Table 3.1).
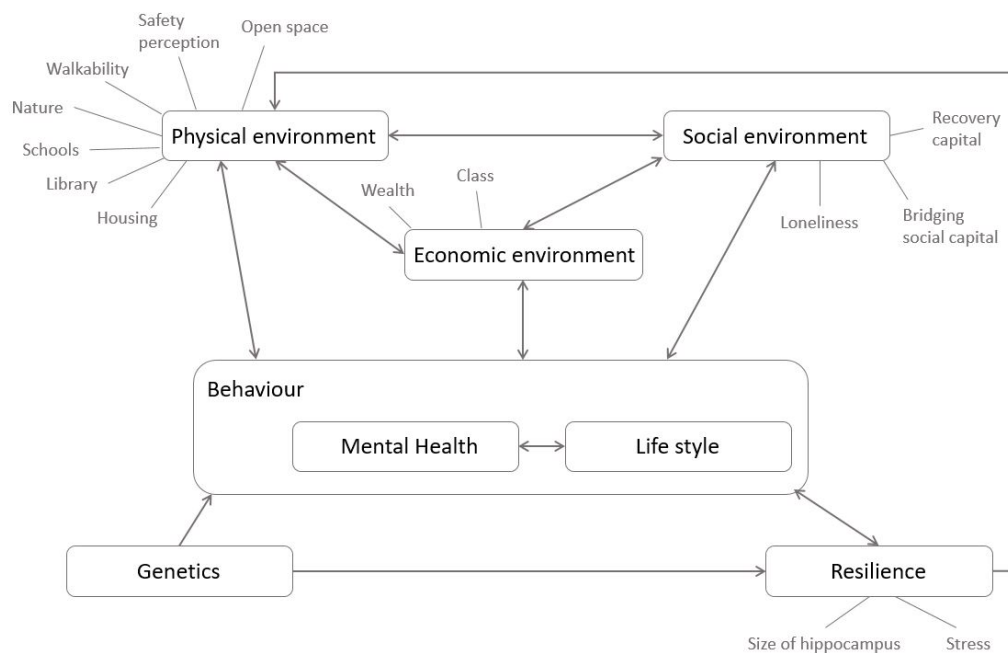
Figure 3.6: Final conceptual framework

Table 3.1: Variables of the concepts

Concept	Variable	Literature
Physical environment	Housing	Gonyea, Curley, Melekis, and Lee (2017); Klinenberg (2018); Lim et al. (2017); Mackenbach et al. (2018); Ochodo, Ndetei, Moturi, and Otieno (2014); Weich, Twigg, Lewis, and Jones (2005); Zahir Izuan, Shamsul Azhar, Tan, and Syed-Sharizman (2018)
	Library	Klinenberg (2018)
	Schools	Klinenberg (2018)
	Nature	Beil and Hanes (2013); Chaney and Stones (2019); Klinenberg (2018); Lane et al. (2019); Maas et al. (2006); Olszewska-Guizzo et al. (2018); Vanaken and Danckaerts (2018)
	Walkability	Hankey and Marshall (2017); Mayne, Morgan, Jalaludin, and Bauman (2018); Wong, Wang, Huang, Huang, and Zhang (2018)
	Safety perception	Astell-Burt, Feng, Kolt, and Jalaludin (2015); Barile, Kuperminc, and Thompson (2017); Klinenberg (2018); Lorenc et al. (2012)
	Open space	Astell-Burt et al. (2015); Barile et al. (2017); Klinenberg (2018); Lorenc et al. (2012)
Social environment	Recovery capital	Klinenberg (2018); Leaf et al. (2012); Stankov et al. (2019); Storr et al. (2012)
	Bridging capital	Barile et al. (2017); Klinenberg (2018); Snijder et al. (2017); Subbaraman et al. (2014)
	Loneliness	Klinenberg (2018); Zock et al. (2018)
Economic situation	Wealth	Martins et al. (2012); Pun, Manjourides, and Suh (2019)
	Power	Hackman and Farah (2009)
Resilience	Size of hippo-campus	Carlson et al. (2012)
	Stress	Al-Barrak, Kanjo, and Younis (2017); Bradshaw et al. (2012); Chrisinger and King (2018); Gonyea et al. (2017); Keane, Magee, and Kelly (2018); Messer, Maxson, and Miranda (2012); Rocha, Ribeiro, Severo, Barros, and Fraga (2017); Rutter (2008); Yehuda et al. (2007)

3.3.4. The role of urban policy making in the framework

When thinking of the influence urban policy-making can have on the framework presented in the last two sections, the physical environment is the concept urban policy-makers can influence most directly. Other measures urban policy-makers can apply, are for example education and awareness, improving health care and community care and financial support. Urban policy-makers can improve the social environment by developing social infrastructure such as libraries and parks, which give the people the opportunity to connect. Besides, municipalities can bridge social capital by for example creating heterogeneous neighbourhoods. The recovery capital can be improved by initiating projects in which people are supported by the community.

Economic gaps can be decreased for example by subsidizing activities for the less wealthy. The development of social housing is another idea for lessening the gap between wealthy and less affluent citizens. Municipalities have the opportunity positively influence lifestyle by creating room for exercise, stimulating the food industry within the city to provide healthier options and education programs. With education, individual stress management can also be improved. Additionally, the mental health of the urban population can be directly influenced by improving community and health care. Genetics is the only concept remaining, that cannot be influenced by urban policy-making.

For this framework is chosen to include all concepts regardless of if and to what extent urban policy-makers can influence the concepts. As introduced in the previous chapter, the

system is complex and interconnected. How an urban component expresses itself in the system, might depend on other variables, including the non-urban. For example, how and if genetic components will be expressed in terms of mental health might depend on if those components are triggered by the other environments. Note that lifestyle is not divided into variables. This because, the focus of the literature was pathways towards mental health in the form of stressors and stress adaptation (resilience) and the connection between the urban environment and mental health (economic, social and physical).

4

Methodology

In chapter 2 the gap between high aggregated theoretical frameworks and low aggregation single variable testing is introduced. For evidence-based urban mental health policy-making, research on the middle level of aggregation is needed. The previous chapter defined a theoretical framework, which will form the basis of the middle level of aggregation research. This chapter elaborates on the methodology used for researching urbanization and mental health, on the middle level of aggregation. This is done by first discussing the research approach (4.1). After this the methods used for the analysis are introduced (4.2).

4.1. Research approach

Earlier in this thesis, health geography is emphasized as a way to connect urbanization characteristics, mental health and space for urban policy makers. However, within the health geography field still several research approaches can be used. This section argues for a deductive approach, because literature shows that it is still unclear how mental health is affected by urban environmental determinants (1.3.1). Aditionally, a mixed-method approach is used combining theory with data (1.3.2). Due to time restrictions, a case is used for modelling the framework (1.3.3). In the previous chapters the complexity has been mentioned, the third chapter elaborates on the approach taken to incorporate the complexity (1.3.4). Finally the general flow of the research will be explained in the last sub-section, research design (1.3.5).

4.1.1. Exploratory deductive approach

The city can be separated into many domains (Batty, 2018; Sennett, 2018), all interacting with the mental health of humans. Especially the link between the social environment and health outcomes has been found to be pace and difficult to summarize (Roux & Mair, 2010). Despite the growing believe that places influences health, there is no consistent evidence of the association between places and health (Fone et al., 2007; Martins et al., 2012; Wong et al., 2018). This has different reasons. Especially conceptualizing and measuring pathways to health decay are found to be challenging (Macintyre, Ellaway, & Cummins, 2002). Place is a "black box" when relates to health (Macintyre et al., 2002, p.125). More sophisticated studies of societal determinants of health focusing on neighbourhood level are needed. This, because the causal pathways underlying the hypotheses about the effect of social factors and neighbourhoods are often not explicit and should be selected carefully from theories. One way to improve causal pathways is to use qualitative research to explore. Studies focusing on neighbourhood level should focus on the actual boundaries of neighbourhoods and the data should be improved and measured following routine (Pickett & Pearl, 2001).

The fact that spacial research about mental health on neighbourhood level is limited and have contradicting results, calls for research that is both exploratory and deductive. A deductive approach is common used in combination with the framework approach (Chapter 3) and is in combination found to be effective for policy health research (Huo et al., 2017).

4.1.2. Mixed-methods

The question how personality and behaviour is influenced by urban life, has been investigated for a long time. In 1095, a time of rapid urbanization, Georg Schimmel published a well known article about *"What impact has city life on the individual's behavior, personality, values, relationships?"* (Takooshian, 2013, p.2). With the help of technologies cities could grow behind natural forces. In 1970 stanly Milgram published an article on *"the experience of living in cities"* (Takooshian, 2013, p.5), in which he describes the model of urban overload and the effect on human behavior. This article forms the basis of modern urban psychology (Blass, 2013; Takooshian, 2013), after which urban psychology theory continued and kept involving. The theories developed by well known urban psychologists are well discussed and developed, however due to limited technological methodologies in the time of these urban psychology theories, validation by modelling was difficult. Recently, the relation between urban concepts and human behaviour is more often statistically validated. Technological developments such as Geographic Information Systems, allow methodologies to research large data-stets and spatial components.

Using mixed-methods gives the opportunity to connect theories and data-sets, to take a holistic approach to urbanization and mental health. By using theory and outcomes from other research, guidance can be derived about how to handle big data-sets, in this case by a theoretical framework. Besides, the combination of multiple methods gives opportunity to validate results and thereby strengthen the statistical results (Jick, 1979). Where the data

provide the research with statistics and estimation of effects, theory adds logic and outcome explanation (Mahoney & Goerts, 2006).

4.1.3. Case study

A case will be used to model the theoretical framework. Studying a single case has the purpose to develop a understanding of a larger class of similar cases (Gerring, 2001). Case studies are often used to get a better understanding of complex social phenomena, like the environmental determinants of mental health. Moreover, case studies are suitable for exploratory research. One limitation of case studies is, that case studies are harder to generalize. This, because the research represents a single case. It is therefore important for to clearly describe the scope and the inquiry of the case. Moreover, the theory component in the mixed methods will contribute to analytic generalization (Yin, 2002).

4.1.4. Adopting complexity

"Open ended gives room to the unknown. Open-systems thinking counsels exactly this kind of mixing: the whole becomes greater than the sum of its parts" (Sennett, 2018, p.42)

The reason why urbanization and mental health research is needed on the middle level of aggregation, is to incorporate the complexity of urban phenomena. Where the research on low level aggregation simplifies on system components, the high level aggregated frameworks simplifies the system relations. Research on the middle level of aggregation must therefore on one hand, incorporate multi-variables, but on the other hand investigate the relations between those variables in depth.

Complex systems are often defined to be non linear systems that are far from equilibrium, in which the whole system is more than the sum of it's parts. They describe higher-order phenomena arising from interactions between different sub-components. Besides this, complexity often goes along with self-organizing behaviour and emergence (Batty, 2018; Boeing, 2018; Sennett, 2018; Tozan & Ompad, 2015). Dynamic systems can be associated to complexity. Dynamic systems are described by interdependence between sub-systems, that have mutual interaction and information feedback. In this system there is "circular causality" between variables (Tozan & Ompad, 2015). In general, all social systems are seen as complex and dynamic systems, under which the urban environment and many of the determinants of mental health belong.

The complexity of cities is described by many authors. The complexity of social systems suggest that cities can be better seen as organisms rather than machines, this theory is described by the urban morphology (Batty, 2018; Colaninno, Alhaddad, & Cladera, 2009). This urban morphology, consists of the stocks and flows of energy, materials and information over time and through space initiated the social and economic systems within the city (Manesh & Tadi, 2011; Zellner, Theis, Karunanithi, Garmestani, & Cabezas, 2008).

This complexity, is also applicable for urban health. However, many epidemiological studies still lack adaptation to this complexity and often use analytical and linear methods. These methods are limited for modelling and analyzing the system holistic due to narrow problem definitions and linear methods (Tozan & Ompad, 2015).

The concept complexity is a trend throughout this thesis. For creating the theoretical framework, the term complexity was used to describe the interconnectedness between concepts, within concepts and between the individual and the environment. Moreover, the system is highly pathway dependent, adding another layer of complexity. Through the analysis, complexity is used to emphasis again on this interconnectedness between many variables. For the policy chapter complexity is used to describe the complex characteristics of this system. One important implication of this complexity for urban policymakers is are the many dilemma's within complex systems and the outcomes of policy actions are unpredictable. A way to deal with this complexity is open thinking, in which prejudices and assumptions are minimized and in which systems are analyzed holistic (Sennett, 2018).

4.1.5. Research design

The process of this research can be summarized into four steps. Additionally, it can be divided into two levels: the case study and the generalization of this case study (Figure 4.1). The first step was to develop a generic theoretical framework (Chapter 3). The second step is to gather case specific data that represents the concepts in the generic theoretical framework (Section 5.1 and 5.2). With this data the theoretical framework will be explored, and a predictive model will be built (Section 5.3 and Chapter 6). The results from this modeling will be connected to policy-making both case specific as generalized and connected with the theory (Chapter 7 and Chapter 8).
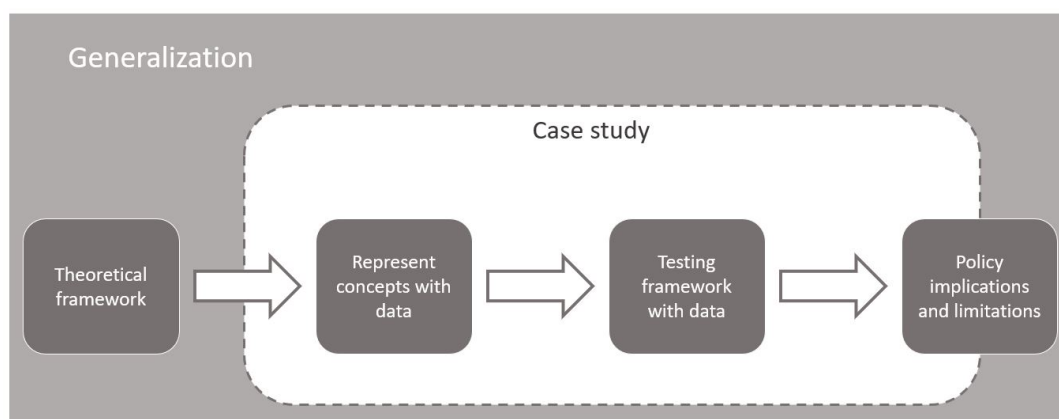
Figure 4.1: Research Design

4.2. Methods

This section describes the general methods used for the analysis. It does not emphasize how these methods are implemented, this will be described in the next chapter (Section 5.3). This section begins with the argumentation of the choice of the main methods (4.2.1). After this, the section will elaborate further on the chosen methods. Negative binomial regression is used for modelling (4.2.2). For data exploration the k-Means algorithm is used (4.2.3). In addition PCA is used to reduce the dimension of concepts (4.2.4). The model is internal validated by analyzing the Pearson residual and by prediction using a train/test split (2.3.5). Finally the results are translated to the political arena by conducting an actor analysis (4.2.6).

4.2.1. Argumentation of methods choice

For exploratory research, methods should be chosen with the least amount of underlying assumptions, simple models are preferred above complex ones (Borovcnik, 1995). For modelling, the negative binomial regression is chosen. Frequentest approach is used, because of the unavailability of prior information. So, in this case a Bayesian would give similar results. Moreover, this the data is all on the same neighbourhood level, a hierarchical model is therefore not necessarily. For the regression a generalized linear model is used. The main difference between generalized linear models and linear models is that the generalized allows the outcome data to be not normal distributed, which is the case with count outcome variables. For this the broader negative binomial family is used instead of Poisson, because of the over-dispersion.

The selected data-set contained to many variables to model at once. To reduce variables, block-wise selection is used in which the blocks are defined based on the theoretic framework of chapter 3.

4.2.2. Negative binomial regression

In the negative binomial regression, the offset will be included. Including offset in the model assumes, that doubling the population will double the count. Which is the case since the population represents the amount of cases analyzed in a neighbourhood. If a model is fitted with an offset, the exponential of the beta coefficients of predictor variables represents the expected rate change multiplicatively for a increase by one variable in the predictor. Thus, the rate will be in terms of counts per one unit of the population (Parry, 2018). Including an offset will improve modelling results, because the neighbourhoods have different sizes.

The negative binomial, models the mean of y by the offset, which is in this case population (p) and a set of k regressor variables (x). The regressor coefficients are unknown (β).

$$\mu = \exp(\ln(p) + \beta_1 x_1 + \beta_2 x_2 + \ldots \beta_k x_k)$$

Subsequently, the regressor coefficients are estimated on the data. In this, each observation is represented by maximizing the likelihood function, based on the following probability function:

$$Pr(Y = y_i | \mu_i, \alpha) = \frac{\Gamma(y_i + \alpha^{-1})}{\Gamma(\alpha^{-1})\Gamma(y_i + 1)}(\frac{1}{1 + \alpha\mu_i})^{\alpha^{-1}}(\frac{\alpha\mu_i}{1 + \alpha\mu_i})^{y_i}$$

In this distribution Γ stands for the gamma function. The negative binomial regression is used for both exploring the relations between the urban characteristics and the mental health outcomes, and variable reduction. For variable reduction an iterative approach of negative binomial regression is used. Regression analysis in general assumes variables to be uncorrelated, to check the correlations between variables Pearson correlation is used (Liang & Zeger, 1993). Besides the relation between variables within the concepts separate and the mental health outcomes, the relations between all the concepts and the mental health outcomes is also investigated. For this, the dimension reduction method principal component analysis (PCA) is used. PCA is computational easy and incorporates all the variables in dimension reduction (Vyas & Kumaranayake, 2006). PCA will be discussed in more depth in Section 4.2.4.

4.2.3. K-Means

K-Means is a clustering algorithm. The algorithm needs two inputs: a data-set and the number of clusters. The first step of the algorithm is to select random estimations for the K centroids. Subsequently the algorithm will integrate between data assignment and centroid update. In the data assignment step, the data points will be assigned to the nearest centroid, based on the squared Euclidean distance. The following equation shows this step, in which ci is the collection of centrioids and x are the data points:

$$\underset{c_i \in C}{\arg\min} \; dist(c_i, x)^2$$

During the centroid update centroids will be recomputed, according the following formula:

$$c_i = \frac{1}{|S_i|} \sum_{x_i \in S_i x_i}$$

So, the centroids are recomputed by taking the mean of all data points assigned to a cluster. This iteration between data assignment and centroid update will continue until a stopping criteria is reached. K-Means is in this research mainly used to visualize results geographically and to the identify and and exploration of the data by comparing variables in neighbourhood clusters (Ahern, Naaman, Nair, & Yang, 2007; Compieta, Di Martino, Bertolotto, Ferrucci, & Kechadi, 2007).

4.2.4. PCA

Principal Components Analysis (PCA) is used, to reduced dimentionality of a large number of variables. The reduced dimension should contain as much information of the original information as possible. With PCA a uncorrelated set of variables is calculated. These are ordered such that the first variables retain the most of the variation of the original variables. So, the first PCA contains the most information, while the last contains the least of information. This weights in maximum variance is calculated by calculating the variance-co-variance(s):

$$s_{ij} = \frac{\sum_{k=1}^{n}(x_{ik} - \bar{x}_i)(x_{jk} - \bar{x}_j)}{n - 1}$$

PCA is used to model the urban concepts (physical, social, economic and lifestyle) represented with one variable, in order to compare the strength of the relation with the mental health outcomes.

4.2.5. Validation

For validation the model will be both internally validated and external validated (generalized). For the generalization, the modeling results will be compared with other research and other cities. Internal validation is done by doing a residuals analysis. This done by using the Pearson residual. Pearson residual differs from the raw residual, because it corrects for unequal variance in the residuals. This is done by dividing the difference between the actual response and the predicted by the standard deviation. The Pearson residual is calculated with the following equation:

$$p_i = \frac{y_i - \hat{\mu}_i}{\sqrt{\hat{\mu}_i + \alpha \hat{\mu_i^2}}}$$

Besides a train/test split is used to validate the predictions of the model, according the following equation:

$$E(y) = exp(predict(model, x_{test}))$$

4.2.6. System and actor analysis

This system and actor analysis is conducted based on the theory discussed in Policy Analysis of Multi-Actor Systems Enserink et al. (2010). The aim of the system and actor analysis is to embed the results in the policy-making arena. System analysis is used to analyze complex systems of policy domains. It helps to structure complex and undefined policy domains. One limitation of the system analysis is that it is usually incomplete. A system analyst must make choices what to include and what to not include. To reduce the effect of this limitation, system analysis will be conducted based on a policy trend analysis. In this policy trend analysis multiple documents of organizations will be analyzed, to make the analysis choices based on the expertise of professionals. To analyses the system the lower "how" part of a means-ends analysis will be used. A means-ends analysis gives insight in the different means that can be used to approach a problem. The upper "why" part of a means-ends analysis is not relevant, since this is already broadly discussed in Chapter 2.

An actor analysis is used to provide insight in the main actors that influence the mental health status within neighbourhoods. This thesis is about providing policy-makers with the necessary knowledge to develop mental healthy policy. It focuses on the link between research and analysis and design. Where research and analysis focuses on facts, design focuses on solutions. This link between research and design is identified as the rational style, in which scientific methods are used to create evidence-based policies. Within this sections actor analysis can help to identify how to mobilize knowledge and information within the system and how this system should be steered into the "right direction". The actors are analyzed based on an actors table, which gives an overview of the actors and their interests.

5

Analysis

Now the general methodological framework is set, the actual analysis can be described. The analysis chapter will form the bridge between the methodology and the actual results. This will be done by first introducing the scope of the case study. Next the theoretical framework will be translated into the data available for the case of Rotterdam. This is done in the Section Conceptualization (5.2). The last section of this chapter will describe the general flow of the analysis and how the methods are implemented (5.3).

5.1. Scope

This chapter introduces the case Rotterdam, which is used as a case for the modelling the relation between mental health and urban determinants. The definition of cities varies among countries, based on population size, density, functions or history (Dijkstra & Poelman, 2012). The first subsection will describe how cities are defined in the Netherlands and elaborates short on the characteristics of Dutch cities (4.1.1). The second subsection will give a short introduction to the city of Rotterdam (4.1.2). Both, with the goal to understand how the results of this case study connects to urbanization and mental health in general.

5.1.1. The Netherlands

About 75 percent of the Dutch population is living in urban areas. With this, the Netherlands is considered to be one of the most urbanized countries in Europe. The Netherlands is highly urbanized, but has a polycentric urban structure. This means that the Netherlands has a small share of metropolitan areas and that most people live in small to medium size towns with small distance from each other. Along with the rest of the world, Dutch cities are predicted to grow strongly. The Randstad has the highest population density in the Netherlands and the urban areas are growing the fastest here. In the four largest cities the share of non-native residents is about the same as the native residents, this is lower in the rest of the country. Just like in many countries, most jobs are in cities. However, compared with other large agglomerations in Europe, the Dutch urban regions are less dense considering jobs. Furthermore, the income distribution differs per city. Where some cities have high income neighbourhoods in the centers, other cities have richer neighbourhoods towards the edge of the city (Nabielek, Hamers, & Evers, 2016).

In the Netherlands, the standardized death rates from mental and behavioural illnesses have been increasing the last decades, while the most other causes of deaths have been decreasing. The mental disorders have the largest contribution to the disease burden. Anxiety disorder and burn-out have for example major impact as they bring limitations to a person over a relatively long period of time. If a mental health disorder is suspected by a person, the general practitioner is the first layer of service in the Netherlands. The general practitioner can give basic mental health assistance or give a referral. The mental health-care in the Netherlands consists of three layers. The first layer is the GP-based mental health care, provided by the general practitioner in collaboration with a mental health practice nurse. The second layer is the Generalist Basic Mental Health Care. Patients are referred to the Generalist Basic Mental Health Care when a DSM-IV disorder is suspected. This layer consists primarily of psychologists and psychotherapists. The third layer is the Specialist Mental Health Care, a patient will be referred to this layer when they have more complex mental health problems (Kroneman et al., 2016).

Health problems are in the Netherlands higher in population groups with a lower socioeconomic status, corresponding to the treds in other countries. Furthermore, lower education has found to have a negative impact on health. Health inequality is a problem in the Netherlands and could be possible explained by unhealthy lifestyle among lower educated populations and populations with a lower socioeconomic status (Kroneman et al., 2016).

5.1.2. Rotterdam

Due to the limited amount of time reserved for the master thesis, the relation between neighbourhoods and mental health will be modelled by using the city of Rotterdam as a case. Rotterdam is chosen as a case because first it is a Dutch city. Secondly, from the four big cities in the Netherlands, Amsterdam, the Hague, Utrecht and Rotterdam, Rotterdam had the most detailed mental health data. Rotterdam is the second largest city of the Netherlands and is geographically divided into 99 neighbourhoods.

Rotterdam is an interesting as a case for modelling the relation between characteristics of neighbourhood inequality and mental health not only because of its' scale but also because it scores on almost all indicators of the health difference monitor on gezondheidsmonitor.nl lower than the average national score. Specific to mental health in Rotterdam 4.6 percent of the population is connected to the "Geestelijke Gezondheidszorg", compared to the 4.0 percent national average (VNG Realisatie, 2019). Besides this, Rotterdam is an industrial city considering the large port of Rotterdam, the logistics and cultures around industry can possibly increase stressors. Geographically, Rotterdam has both area's of high density in the city centre and lower density on the edge of the city and has area's with modern high rise buildings in the city centre, and neighbourhoods with more characteristic houses such as in Blijdorp. This, because of the city's history in the second world war. In the first section of the results presents the data exploration results in which the characteristics of Rotterdam will be further introduced.

5.2. Conceptualization

This conceptualization translates the theoretical framework into the data for the city of Rotterdam. This translation will be done in the Subsection Proxies (5.2.1). However, through limitations in the data availability the theoretical framework could not be translated without having some limitations. Those limitations will be described in the second subsection (5.2.2).

5.2.1. Proxies

The representation of the theoretical framework by data is dependent on the available open data considering neighbourhood characteristics and mental health characteristics. A full description overview of the retrieved online data can be found in the data dictionary (Table B.1, Appendix B). For gathering the data four web-sides are used. Those sources are data.overheid.nl, rotterdam.buurtmonitor.nl and gezondheidsatlasrotterdamrijnmond.nl.

Mental health is a theoretic concept, and there are many ways to measure mental health dependent on modelling assumption and the availability of data. The source, "gezondheidsatlas" has published mental health data on neighbourhood level. Four data-sets were interesting as mental health indicators. Those indicators are: satisfaction

with life, burn-out, anxiety disorder and depression (Figure 5.1). All those mental health indicators provide information about mental health status in neighbourhoods, but have different symptoms and could have different relationships with the environment. Because it is not clear how those different mental health disorders come together they are modelled separately. Moreover, the assumption that all mental health disorders have the same risk factors would violate the open system approach to complexity (Section 4.1.4).
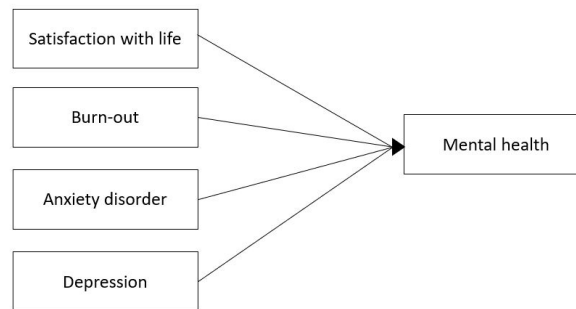
Figure 5.1: Mental Health

On the next page the data availability for each of the neighbourhood characteristics groups, population characteristics (Figure 5.2a), lifestyle characteristics (Figure 5.2b), social environment characteristics (Figure 5.2c), physical environment characteristics (Figure 3.5d) and the economic situation (Figure 5.2e) are visualized. The theoretical framework of Chapter 3, show some differences compared to the data conceptualization in this chapter. Walkablity is not represented in the physical environment. This, because no such data-set existed in the open-data sources. Besides, a typical characteristic of Dutch cities is that they are compared to other countries all of high walkable standard. Another difference in the physical environment is that the open space is not represented along with the library and schools. This, because especially schools and libraries, have influence on cities beyond neighbourhood boundaries. The housing within neighbourhoods are represented by value, amount of rooms, rental or bought, surface and occupancy. Neighbourhood facilities are represented by the amount of shops, and nature by the percentage of people that think there is enough greenery nearby. Safety is in contradiction to the framework of Chapter 3 not placed within the physical environment, but in the social environment, because the data represents the amount of crimes and not the safety perception. Furthermore, the three social capital variables are represented in the data with a single social cohesion variable. The economic environment was divided into wealth and class. The class could be interpreted by education and the remaining variable are mainly representing the wealth side of the economic environment.
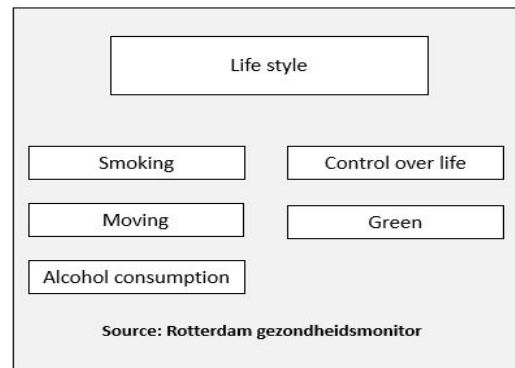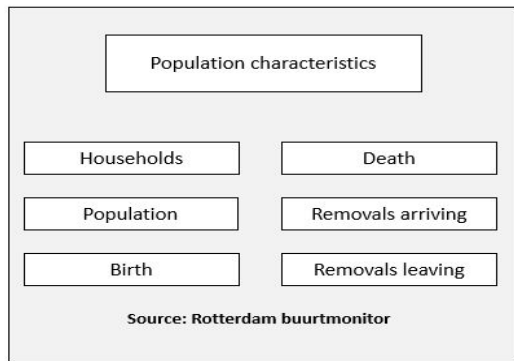
(a) Population characteristics

(b) Lifestyle characteristics
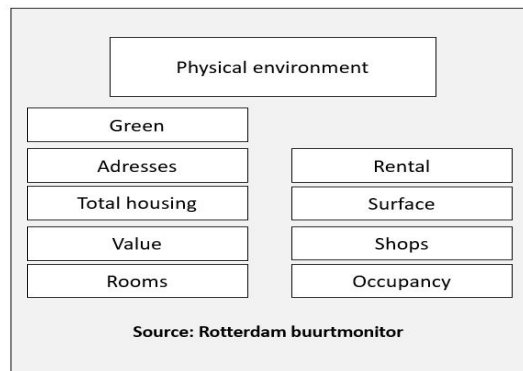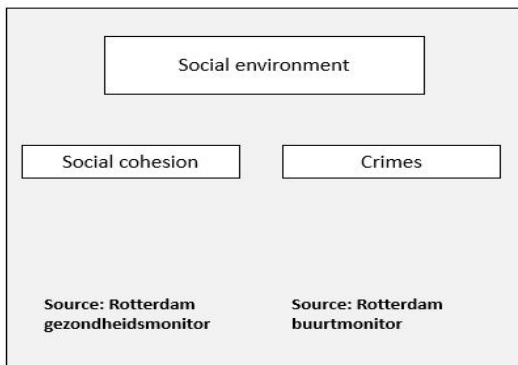
(c) Characteristics social environment

(d) Characteristics of the physical environment
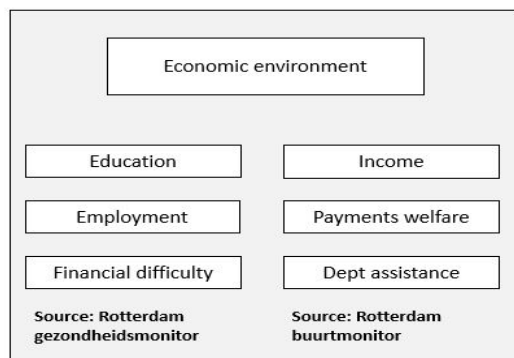
(e) Characteristics of the economic situation

Figure 5.2: Defining neighbourhood characteristics per concept

5.2.2. Data limitations

The available open data relevant for investigating the link between characteristics of neighbourhoods and mental health brings two main general limitations. The first limitation is that the data is on neighbourhood level. Although politics identify this as boundaries, it might not be representing the real geographical distribution of the variables (Pickett & Pearl, 2001), which could lead to weaker results. The second limitation is that only the environmental and life style factors influencing mental health can be represented by the data. The influence of genetics and resilience on the mental health can not be represented by the model. However, these limitations do not make data analysis irrelevant. Although the distribution of the people might not follow neighbourhood boundaries. Democracy, public participation and policy is often organized and developed within the boundaries of districts and neighbourhoods within a city. Besides, although not all concepts of the theoretical framework can be represented by data, all environmental concepts are represented. These environmental concepts are what urban policy-makers interest the most.

Moreover, the mental health data resulted from the "Gezondheidsmonitor Volwassenen en Ouderen" research of the RIVM in 2016. This study was on national level, with the goal to gain more data about the health and lifestyle of people. This data was gathered trough questionnaires. Perceptions of mental health disorders might differ among people and among social groups. The diagnosis of a psychologist might be more rational, than a self-diagnose. This irrationality can have influence on the quality of the data. On the other hand, the fact that people have mental health problems does not necessarily mean they are registered by a psychologist, particularly considering the "softer" mental disorders such as depression, anxiety disorder and burn out. With a questionnaire, these people are reached too. Besides this, the study did had limited responses. The RIVM used a structured additive regression model to estimated individual outcomes based on predictive characteristics. The limited responses might influenced the data quality. However, the validation of the estimation model gave good results, which indicates this effect is limited (van de Kassteele, Zwakhals, Breugelmans, Ameling, & van den Brink, 2017).

Finally, the predicting variables have some limitations too. First, not all variables represent the 2016. For example, the latest available data for income represents 2014 along with many of the physical environment variables. Second, not all individual data represents the same age groups. Education level is measured between the age of 15 and 75, while social cohesion measures the age group between 19 and 65 and most of the life style variables measures 19 years and older. The mental health outcomes measures the age group 19 years and older. This might affect the results, because individual in the age group above 65 might show significant other characteristics than the age group below 65. By representing the full range of ages above 19 years by characteristics with smaller age-groups, it might misrepresent the population group. Another limitation exists in for example the social cohesion, which measures social cohesion and groups it in three categories. This three categories of social cohesion, reduces the dimension of social

cohesion.   This approach to measure social cohesion reduces information and the representation might be to abstract to measure relationships.

5.3. Implementation of the modelling methods

In the section 4.2 the methods are introduced used in this research. This section continues on those methods by the describing how they are implemented. The figure below describes the modelling process in three phases (Figure 5.3).   The programming languages and packages used for the implementation of the modelling methods can be found in the appendix (Appendix D, Table D.1 and D.2).
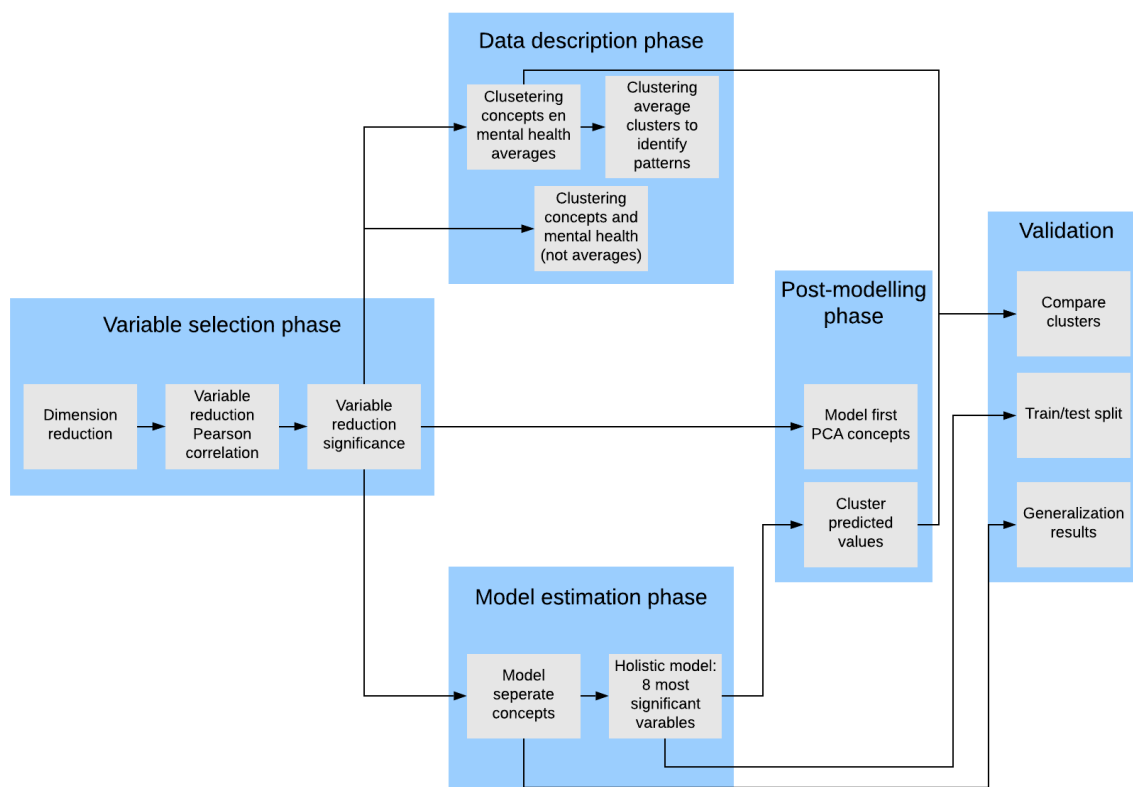
Figure 5.3: Flow chart modelling process

This section will first describe the variable selection phase (5.3.1), followed by the data description phase (5.3.2). The third phase described in this section is the model estimation phase (5.3.3). After which the post-modelling phase will be discussed (5.3.4). The filth section, interconnectedness, is not visualized in the above flow diagram (5.3.5). This because, it follows the same process of the model estimation phase with different data. The last section describes the validation (5.3.5). The different tasks in in each phase are indicated by steps, those steps does not always indicate dependency. The dependency between tasks are indicated in Figure 5.3. The steps indicate the sequence in the implementation of the tasks and is communicated to divide the phases clearly for the reader.

5.3.1. Variable selection phase

The aim of the variable selection phase is to reduce the number of variables to be considered in the modeling step. Too many variables and/or highly correlated variables will result in unstable models when the number of observations is relatively small. The variable selection phase can be divided into three steps: dimension reduction for concepts with too many variables, variable selection based on Pearson correlations and variable selection based on significance in the model. In the first step of the variable selection phase and the third step of the variable selection phase modelling is used. It could therefore belong to the modelling phase. However, both steps are needed for the data description phase. Moreover, the aim of those two steps comply with the general aim of the variable selection phase. Therefore, those steps are included in the variable selection phase instead of the modelling phase.

The first step of variable selection was to model the five environments and their mental health outcomes in order to check the model performance. During this first step of variable selection it became clear that the physical environment had too many variables. The original physical environment contained variables that where split into multiple. For example the amount of rooms in a house was split into 1 room, 2 rooms, 3 rooms etc. Those split variables all represented the percentage of houses in the neighbourhood with this amount of rooms. To reduce those variables, the amount of rooms was translated into categories. One room,became 1, two rooms became 2, etc. From those categories the one with the highest percentage was selected for the respective neighbourhood. Thus, the room variable now represents the most frequent house layout for the neighbourhood. The same method is used to reduce the surface of the houses variables, the value of the houses variables and the age of the houses variables. After reducing the amount of variables, the negative binomial regression worked. A description of the data after processing can be found in the Appendix(Appendix B, Table B.2).

The next step was to reduce variables based on the Pearson correlations. Variables would be removed from the data if they have both similar variable descriptions and a high Pearson correlation. This, in order to remove sets of variables that describe similar phenomena.

The last step of variable reduction is to reduce variables based on insignificance. This step modelled the five urban concepts separately for each mental health outcome. Based on the modelling results, variables were removed if they showed a P-value above 0.05. The result after this final step step is 25 data frames which all start with one of the five mental health outcomes combined with the one of the 5 concepts from the theoretical framework. So, one data frame consists of for example anxiety disorder and the economic environment, while another contains burn out and the social environment. Those data-frames only consists of significant variables for the respective mental health outcome.

5.3.2. Data description phase

The aim of the second modelling phase is to explore and give descriptions of the data for interpretation and generalization of results from the multiple regression models. For this phase the data-set after the second step of variable reduction was used, minus the variables that were insignificant for all five mental health outcomes. If a variable was not insignificant for all variables, but insignificant for one or more this variable is still included in the data descriptive phase. Thus the data-set used for the data description phase is different than the data used for the modelling phase. Because the aim for the data description phase is to look at neighbourhood patterns, it is not necessary to compile different data-sets for each mental health outcome. However, for the modelling phase it is necessary that each mental health outcome is modelled with only the respective set of significant variables. Before clustering the neighbourhoods based on the data, the data should have either all positive or all negative assumed relation with mental health. Because the mental health is measured by mental health disorders, the negative relation was chosen. Subsequently this negative relation was assumed based on the expected impact it would have on stressors in a neighbourhood (Table E.1, Appendix E). This because, stressors are assumed to affect mental health negatively (Section 3.2). The next general step is to re-scale the data between 0 and 1 using the min max possessor. After this the data is clustered using the k-Means algorithm.

The aim of the first step of the descriptive phase was to geographically compare mental health outcomes with the five concepts. With the algorithm, the mental health outcomes, and the five concepts: life style, economic environment, social environment, physical environment and population characteristics are clustered and geographically visualized. For this step for each concept and the mental health outcomes, the average of all variables is taken. Based on those averages clusters are assigned with the k-Means algorithm. To compare the performance of the neighbourhoods, the cluster must represent how "negative" this neighbourhood performs, rather than the common patterns in neighbourhoods.

The next step of the descriptive phase, is to cluster the outcomes of the first step. During the previous step clusters were assigned to the neighbourhoods on mental health outcomes and the concepts: economic environment, physical environment, social environment and lifestyle. For this step those clusters were combined into one data frame. Subsequently this data frame was re-scaled and clustered. With the previous scores of neighbourhoods new clusters are assigned in order to identify patterns in the performance of mental health and the five concepts per neighbourhood.

The last step step of the descriptive phase was to analyze the mental health outcomes and the five concepts. For this the neighbourhoods are clustered for each mental health outcome in which all variables are re-scaled and clustered. In contradiction to the first phase the clusters represent patterns and not the performance. For this clustering step, the data without assumptions is used. For this cluster step a higher value for a variable indicates a higher amount of this variable, not the performance.

5.3.3. Model estimation phase

In the model estimation phase can be divided into the modelling of the urban concepts separately and the holistic model. From the data frames that resulted from the variable selection formulas are generating according to the following form:

$$Outcome \sim factor_1 + factor_2 + ... + factor_k + offset(log(population))$$

In which the outcome is one of the five mental health outcomes and the factors are representing the concepts.

The first step of the modelling estimation phase is to model all significant variables for each mental health outcome and concept. Thus, in this step 25 models will be estimated.

The second step is to model all concepts combined for each mental health outcome. Because there are too many significant variables for each mental health to model, the eight most significant variables will be selected, based on the P-value. Models will be estimated based on those eight most significant variables. In this step 5 models will be estimated, one for each mental health outcome.

So, the difference between the first step and the second step of the modeling phase is that in the first step all significant variables are modeled, but modeled for each concept differently. In the second modelling step the eight most significant variables are selected for each mental health outcome for all concepts combined. In the second step each mental health outcome is modelled by only one model in which include variables from all concepts.

5.3.4. Post-modelling phase

The post-modelling phase can be divided into two steps: clustering based on predicted values and the comparison of the relations between concepts and mental health outcomes. Those two steps have different goals. The goal of clustering predicted values is to explore how the model would perform in predicting mental health outcomes if a data set of a different city would be used. The aim of this step is for policy-makers to identify "problematic neighbourhoods" if they would posses new data. The goal of the comparison of the relations between concepts and mental health problems is to identify on which concept urban policy-makers should focus, when addressing mental health issues.

For assigning clusters on neighbourhood based on the predicted values, the predicted values of the holistic model are used. These predicted values were estimated in the first step of the model estimation phase. Subsequently the neighbourhoods are clustered using the same process in the first step of the data description phase. The predicted values are first averaged per neighbourhood. After which they are re-scaled and clustered.

For the comparison of the relations between concepts and mental health outcomes the same significant data-set is used as for modelling the second step of the model estimation phase. To able to compare the strength of relation between the concepts and the mental

health outcomes, each concept should be represented by one variable. PCA is used to reduce the dimension of each concept. Subsequently the model will be estimated according the following formula:

$$Outcome \sim concept_1 + concept_2 + \dots + concept_5 + offset(log(population))$$

5.3.5. Interconnectedness of concepts

To gain a better understanding of the interconnectedness of the system some variables of the eight significant coefficients will be selected based on relevance. The interconnectedness will be analyzed by repeating the model estimation phase.

5.3.6. Implementing validation

The last step of the modelling is the validation. It consists of two phases: the internal validation and the generalization. The fist step of the validation is the residuals analysis. For this the Pearson residual will be plotted against the linear predictor to validate the model fit. The second step of validation is to use a train / test in which 20 percent will be predicted based on the model training on 80 percent data set. For the generalization, the modeling outcomes will be first validated with the outcomes of other research. Secondly the holistic model of phase 3 to compare clusters of the predicted values with clusters of the real values.

6

Results

This chapter presents the results of the analysis as described in Section 5.3. For this chapter, a similar as the implementation section is used. The first section will describe the results from the variable selection phase (6.1). The next section describes the data description phase (6.2). Next, the results of the model estimation phase will be described (6.3). After which, section four presents the post-modelling phase results (6.4). This chapter ends with the validation results (6.5).

6.1. Selected variables

The variable selection phase is divided into the three steps: dimension reduction, variable selection based on Pearson correlations and variable selection based on significance. This section describes the results for the second and third step. The data set of the physical environment after dimension reduction is included in the data description phase and will not be discussed in this section.

The Pearson correlations for each concept are visualized in the appendix (Appendix C.1, Table C.1 till C.5). Variables are removed if they have similar variable description and high correlation. Variables that met those conditions were: removals arriving and removals leaving, measuring both moving patterns within a neighbourhood. Naturally,when a person decides to move out of a neighbourhood often a new person will shortly after move into this house. Especially considering the shortage of houses in Dutch city. This expectation of removals leaving and removals arriving measuring the same phenomena is confirmed by the correlations, which are above 0.9. Based on these findings Removals leaving was removed from the population characteristics concept. Another variable that is expected to measure the same is inhabited addresses and total housing, for the exact same reason of

housing shortage those to variables are expected to measure the same. This expectation was confirmed by the correlation results, which had a value above 0.99. The last group of variables are the loneliness variables in the social environment. The social environment has four variables measuring loneliness: Moderate to very lonely, seriously lonely and social lonely. Indeed the correlations show that they are highly correlated. For the social environment the two loneliness with the lowest correlation in-between remained in the data set and Moderate to very lonely and social lonely were removed.

After the Pearson correlation variable selection, variables are further reduced based on significance. The variables that were insignificant for all five mental health outcomes are: social cohesion, smoking, green is important and handle financial. A full overview of the removed variables per mental health outcome can be found in the appendix (Appendix D, Table D.3).

6.2. Data description

This section gives a description of the data which is the result of the process described in the previous chapter (Section 5.3.2). The data set represents a sample of 52 neighbourhoods, five mental health outcomes and 36 variables (Table 6.1). This section will present the neighbourhood clusters based on the averages of concepts and mental health outcomes (6.2.1). Next it will describe the neighbourhood clusters after clustering the average clusters (6.2.2). The last subsection describes the neighbourhood clusters for the mental health outcomes and concepts (6.2.3). For this clustering step no averages are used.

Table 6.1: Variables of concepts and mental health outcomes

	Variables
Mental health outcomes	Anxiety disorder, burn-out, depression, min 1 psychological disorder and not happy
Population characteristics	Death, removals arriving, single parent, single person, couple with kids and couple without kids
Lifestyle	Smoking, excessive drinker, heavy drinker, moves sufficiently, exercise standard, green is important, control over life and handle financial
Social environment	Social cohesion, total crimes, seriously lonely and emotional lonely
Physical environment	Enough greenery, total housing, value houses, rent houses, surface houses, occupancy overcrowded, room houses and shops
Economic environment	Income, social welfare, payments welfare, debt assistance, no basic education, secondary education, high education and unemployed

6.2.1. Clusters averages concepts and mental health outcomes

This section presents the results of the clustering of the averages for the mental health outcomes and the five concepts: population characteristics, lifestyle, social environment, physical environment and economic environment. The purpose of clustering the averages is to represent "worse performing neighbourhoods" with a higher cluster number. Figure 6.1 visualizes the results of this step in the data description phase. This subsection gives first a description of the mental health outcomes and concepts separate. Next, the plots will

compared.

Looking at the mental health, the problematic neighbourhoods are situated around the city center (figure 6.1). Thee changes in population characteristics are low on some of the edge neighbourhoods in Rotterdam (figure 6.1b). The lifestyle in general is worse in the city centre and some lower neighbourhoods in Rotterdam, compared to the higher edge neighbourhoods (figure 6.1c). Social cohesion is particularly low in the lower part of Rotterdam (figure 6.1d). The physical environment can be described to be more tight in the city center and some of the lower neighbourhoods (figure 6.1e) Economically, Rotterdam has a few richer neighbourhoods around the city center, but in general the richer neighbourhoods are placed on the top edge of the city, while neighbourhoods between the city center and the lower edge are poor (figure 6.1f).

The following describes a comparison of the mental health outcomes with the concepts, based on the highest cluster. This highest cluster indicates the "worst performing neighbourhoods" based on the assumptions (Table E.1, Appendix E).

The Neighbourhoods with the highest cluster based on population characteristics, include all neighbourhoods with the highest cluster number of mental health. However, the population characteristics show far more cluster four neighbourhoods. Comparing the other clusters, the population characteristics show differences relative to the mental health outcomes.This includes cases of assigned neighbourhood clusters lower than the cluster of mental health outcomes as well as the other way around.

The third plot, lifestyle shows a few cases in which neighbourhoods got the same clusters assigned for the mental health outcome and the lifestyle data. These similar assigned neighbourhoods can be mainly found in the lower clusters, thus the "better performing" neighbourhoods. The highest clusters of the lifestyle data show no similarity with the mental health neighbourhood clusters.

The highest neighbourhood cluster group of the social environment show only one similar case with the mental health outcomes clusters. Furthermore there can be noticed that the upper part of Rotterdam shows similar cluster assignment in the social environment compared to the mental health outcomes. When comparing the lower part of Rotterdam, the social environment and the mental health outcomes show many different assigned neighbourhoods.

All neighbourhoods which got assigned with the highest cluster, are also assigned with the highest cluster in the physical environment. When looking at the center of the city, the neighbourhoods got in general higher assigned clusters compared to the assigned neighbourhood clusters for mental health outcomes. For the neighbourhoods towards the edge of the city, neighbourhoods got higher clusters as well as lower clusters or the same clusters assigned.

The last environment visualized in Figure 6.1 is the economic environment. Notable here is that in contradiction to lifestyle, the economic environment shows higher clusters in the

lower parts of the city and lower clusters in the upper part of the city compared to the mental health outcomes. Considering the neighbourhoods that got the highest cluster assigned for mental health outcomes, three out of four neighbourhoods also got the highest cluster assigned in the economic environment.

(a) Mental health

(b) Population characteristics

(c) Lifestyle characteristics

(d) Characteristics social environment

(e) Characteristics of the physical environment

(f) Characteristics of the economic environment
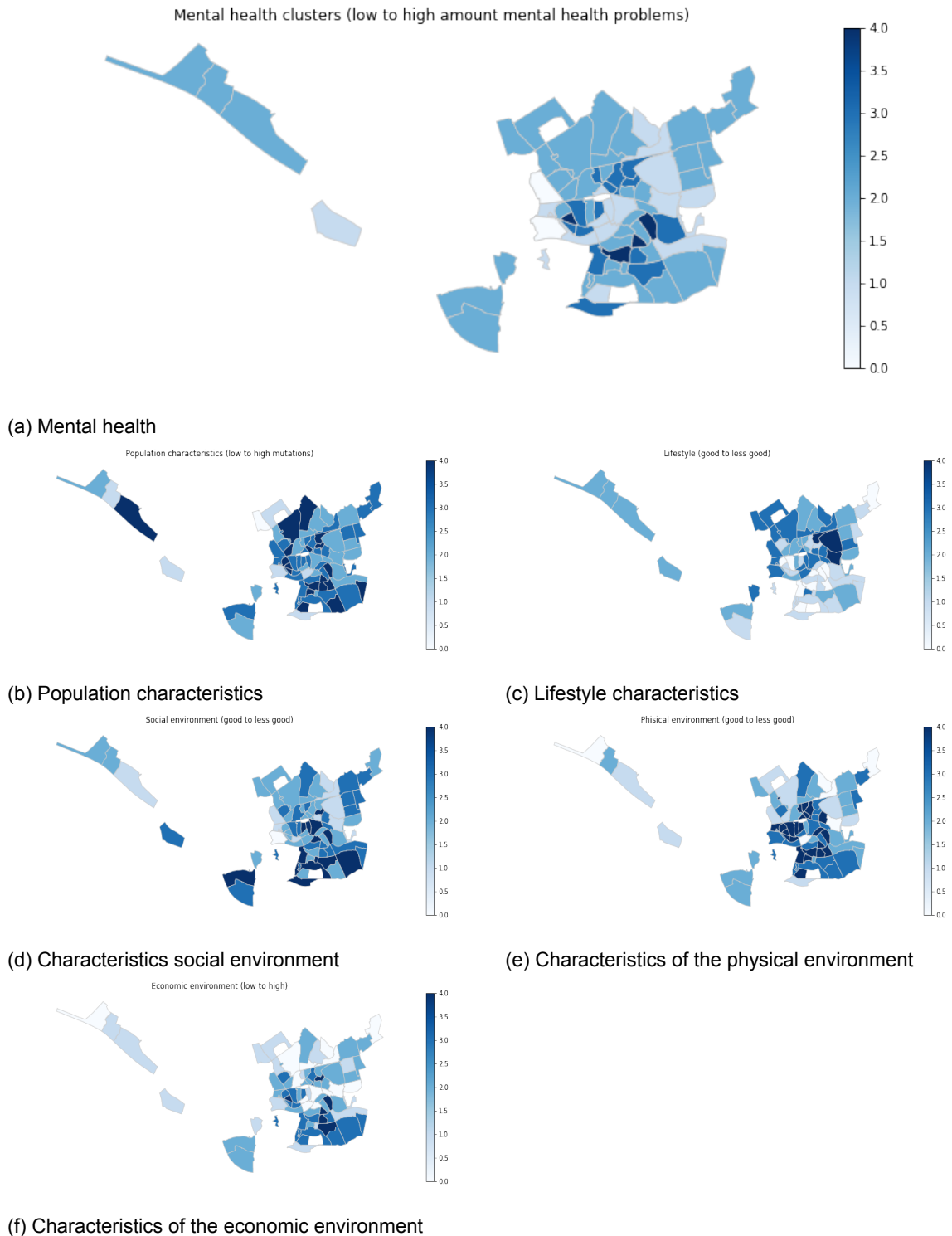
Figure 6.1: Plot of cluster analysis concepts and mental health outcomes

6.2.2. Clusters of the average clusters

The figure below (Figure 6.2) shows the result of the clustering of the neighbourhood clusters of the mental health outcomes and the five concepts. In this figure the average value for each concept and the mental health outcomes are presented per cluster. Cluster zero show high values for all concepts and mental health outcomes, with the exception of lifestyle. The first cluster has a high value for population characteristics and lifestyle, a low value for physical environment and economic environment and an average value for the mental health outcomes and the social environment. In cluster two the values for mental health, lifestyle, physical environment and population characteristics are similar. In this cluster social environment has a higher value, while the economic environment has a lower value. Cluster three has higher values for lifestyle, physical environment and population characteristics and similar values for mental health outcomes, the economic environment and the social environment. In cluster four the population characteristics and the social environment have similar values compared with the mental health outcomes. Lifestyle and the physical environment have higher values, while the economic environment has a lower value.

There can be noticed for all clusters in general that the amount of cases the concepts show higher or similar values compared to the mental health outcomes are similar. There are less cases where the concepts show lower values in the clusters. This can also be noticed in the figure of the previous subsection (Figure 6.1). The economic environment is the environment which show the most cases in which they show a lower value than the mental health outcome within a cluster (Figure 6.2). When comparing this result with the previous subsection the economic environment indeed show the most neighbourhoods with a low cluster (Figure 6.1f).
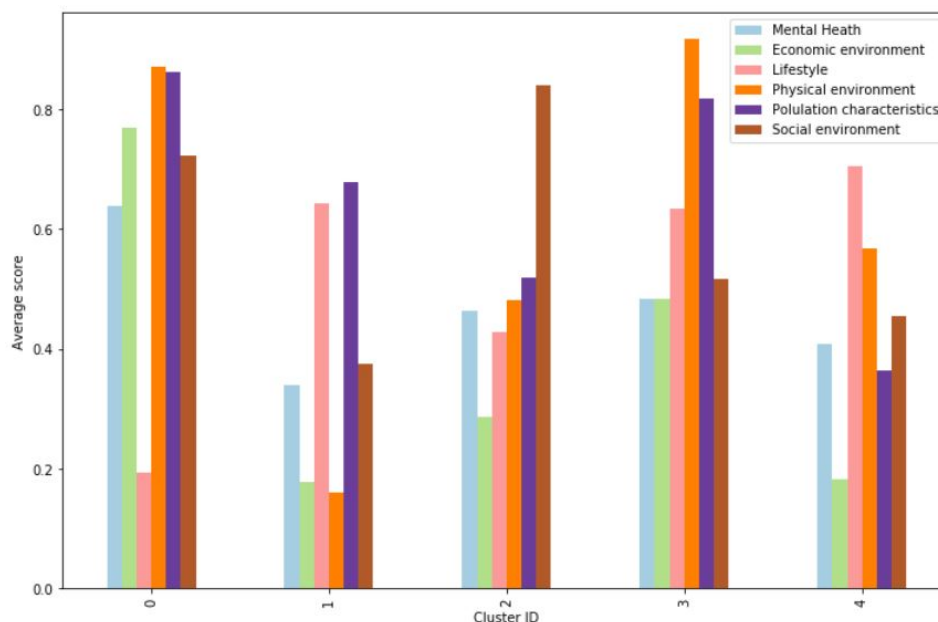
Figure 6.2: Cluster analysis of clusters Figure 6.1

6.2.3. Clusters concepts and mental health outcomes

In contradiction to the first subsection of the data description (Section 6.2.1), the values of the concepts and mental health outcomes are not averaged before clustering. The clusters here show neighbourhood groups with similar characteristics for a concept or the mental health outcomes, instead of the "performance" of a neighbourhood. These figures can be found on page 52 (Figure 6.3).

The neighbourhood clusters for the mental health outcomes show similar values (Figure 6.3a). Within these clusters either not happy or anxiety disorder show the lowest value. Burn-out, minimal 1 psychological disorder and depression got in general the higher numbers assigned.

The population characteristics show less similarities within clusters compared to mental health (Figure 6.3b). When analyzing the clusters, birth always show a higher number where deaths has a lower number and the other way around. Cluster four is an exception on this and got a higher value for death compared to birth. Notable is that the first two clusters show relative similar patterns. In those clusters death, single person and removals arriving are low. Neighbourhoods in these clusters have high values for birth, single parents, couple without kids and couple with kids. The remaining three clusters show less similarities, although they all have a higher value for single person compared to the first two. Besides this, cluster two has a average value for removals arriving and couple without kids. Neighbourhoods with cluster three have low values for birth, death, single parent and couple with kids. Cluster three has higher number for birth and couple without kids, an "average" value for single person, single parent and couple without kids. Furthermore, this cluster has a low value or death and removals arriving. The last cluster has an high value for death, average value for single person and low value for birth, couple without kids, removals arriving, single parent and no couples with kids. This cluster shows a value of zero for couple with kids. The last cluster shows a high value for single person and couple without kids an average value of removals arriving and a low value for birth, death, single parent and couple with kids.

The next figure in the plot visualizes lifestyle (Figure 6.3c). In general all clusters show a different pattern for lifestyle. However, moves sufficiently and exercise standard show similar values within the clusters, with the exception of cluster two. Neighbourhoods in cluster zero have high values for moves sufficiently and exercise standard. This cluster shows lower values for excessive drinker, heavy drinker and control over life. Cluster one have comparable values for all variables. Cluster two show high values for exercise standard and control over life. Within this cluster, excessive drinking, heavy drinker and moves sufficiently show lower values. Cluster three has a high value for excessive drinker and heavy drinker and show low values for moves sufficiently, exercise standard and control over own life. The last luster have high values for excessive drinker, heavy drinker, moves sufficiently and exercise standard. Control over own life is the only low variable within this cluster.

The fourth plot shows the neighbourhood clusters for the social environment (Figure 6.3d). Seriously lonely has a value that is in each cluster a similar amount lower than emotional

lonely. Total crimes are low in all the clusters, except in cluster two.

The clusters of the physical environment is the fifth plot in the figure (Figure 6.3e). In general the clusters show a worse value for the surface of the houses compared to the rooms of the houses. The variable room houses show a high value in all clusters. The variable shops has a low value in all the clusters, this also applies for occupancy overcrowded. Furthermore, neighbourhoods in cluster one have enough greenery. In these neighbourhoods there are more rental houses than bought houses. The total housing is low along with the value of the houses and surface of houses. Neighbourhoods in cluster one have more bought houses compared to rental. Besides, this cluster shows high values for greenery, value o the houses, surface of the houses and rooms of the houses . Total housing is low in this neighbourhood. Neighbourhoods in cluster two have also more bought houses than rent. However, values of the houses and amount of rooms of the houses are lower. Cluster three shows a relative low value for all variables. The value of the houses in these neighbourhoods are lower than in cluster two. Furthermore, the neighbourhoods have more rental houses than bought houses. The final cluster shows high values for all the values, except occupancy overcrowded, total housing and shops. This neighbourhood has more rental house, than bought houses. Furthermore it is the only cluster with a higher amount of rent houses and a higher number for the value of the houses.

The last cluster plot is for the economic environment (Figure 6.3f). Cluster zero and cluster three show high values for all the variables, except for high education in cluster zero. Cluster one has low values for special welfare, payments welfare, no basic education and unemployed. The variables income, secondary education and high educations have high values for the neighbourhoods within this cluster. Cluster two shows low values for all variables and cluster four show average values for special welfare, payments welfare, high education and unemployed. The values for income, no basic education and secondary education are relatively high within this cluster.

(a) Mental health

(b) Population characteristics

(c) Lifestyle characteristics

(d) Characteristics social environment

(e) Characteristics of the physical environment

(f) Characteristics of the economic environment
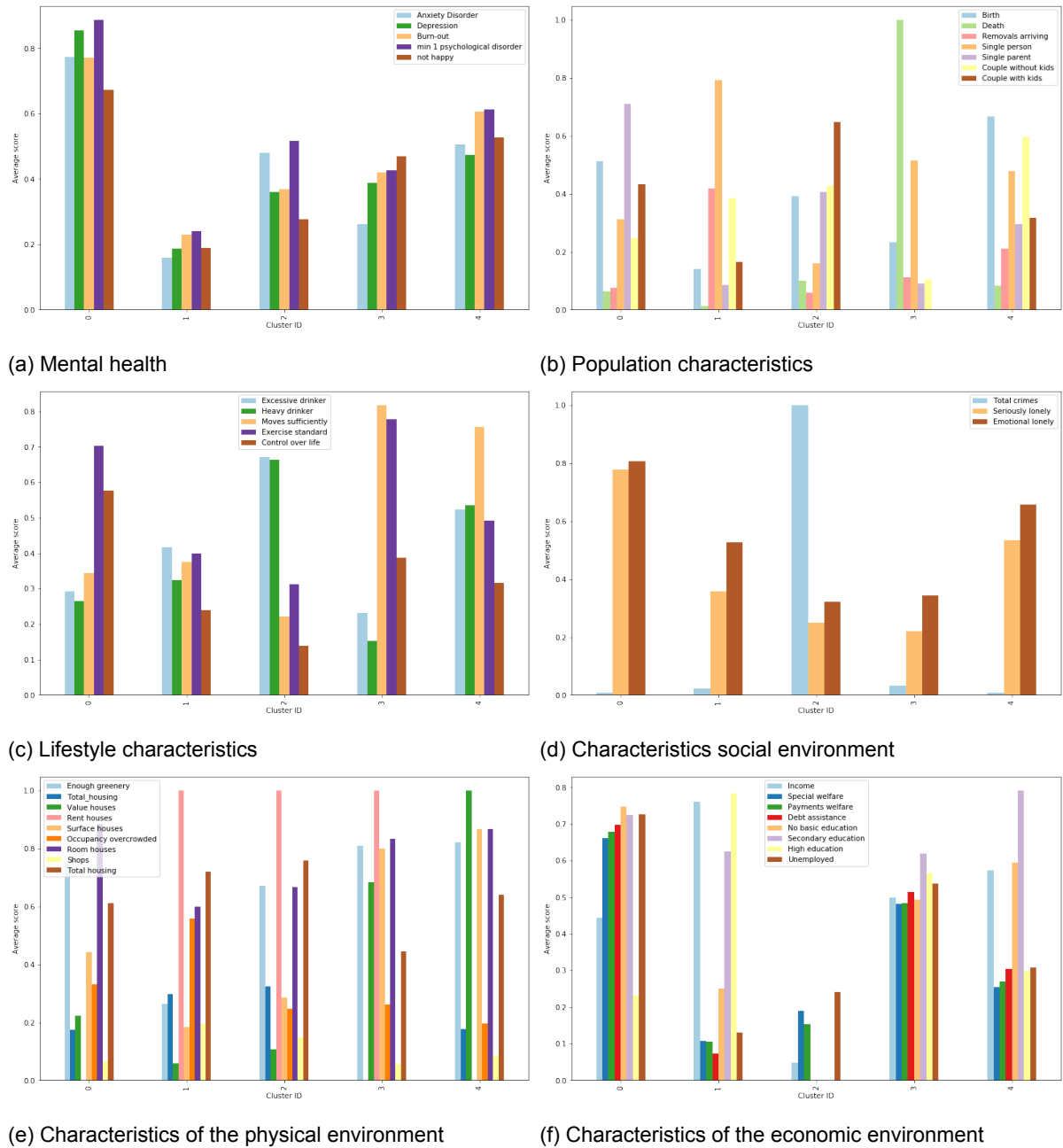
Figure 6.3: Plot of cluster analysis concepts and mental health outcomes

6.3. Model estimation results

As described in section (5.3.3), the model estimation process can be divided into all significant variables and the eight most important variables.

6.3.1. Significant variables

The relationship between all five mental health outcomes and the covariates selected in Section 6.1.1 are considered using the negative binomial model. A description of the modelling results of all significant variables can be found in the appendix (Appendix F.1, Table F.1). All significant variables are visualized in the figure below (Figure 6.4). In this figure the coefficients are colored green when a higher value for that variable means a lower mental health outcome. The orange colored coefficients are for the cases when a higher value for the variable means a higher mental health outcome. According to the analysis, all education levels have negative influence on mental health outcomes. From the household types, only couples without having have positive relations with mental health outcomes. The rate of inhabitants that assess the greenery in the neighbourhood to be sufficient decreases the amount of mental health problems in a neighbourhood. Overcrowding is negatively associated with mental health problems, together with crimes in a neighbourhood and loneliness. The availability of shops, room size of houses and value of houses is positively associated with mental health. Although the significance within neighbourhoods differ, the direction of the relationship is similar for the same variable in every mental health outcome. Remarkable is that excessive drinking is positively associated with mental health in this model.

Anxiety disorder	Burn out	Depression	Min 1 disorder	Not happy
Income	Income	Income	Income	Income
Special welfare	Special welfare	Special welfare	Special welfare	Special welfare
Payments welfare	Payments welfare	Payments welfare	Payments welfare	Payments welfare
Debt assistance	Debt assistance	Debt assistance	Debt assistance	Debt assistance
No basic education	No basic education	No basic education	No basic education	No basic education
Secondary education	Secondary education	Secondary education	Secondary education	Secondary education
High education	High education	High education	High education	High education
Unemployed	Unemployed	Unemployed	Unemployed	Unemployed
Exessive drinker	Exessive drinker	Exessive drinker	Exessive drinker	Exessive drinker
	Heavy drinker			Heavy drinker
		Exercise standard		Exercise standard
Moves sufficiently	Moves sufficiently			
Control over life		Control over life	Control over life	Control over life
Death	Death	Death	Death	Death
Removals arriving	Removals arriving	Removals arriving	Removals arriving	Removals arriving
Single person	Single person	Single person	Single person	Single person
Single parent		Single parent	Single parent	Single parent
Couple without kids	Couple without kids	Couple without kids	Couple without kids	Couple without kids
Couple with kids	Couple with kids	Couple with kids	Couple with kids	Couple with kids
Enough greenery	Enough greenery	Enough greenery	Enough greenery	Enough greenery
Total housing	Total housing	Total housing	Total housing	Total housing
Value houses	Value houses	Value houses	Value houses	Value houses
Ownership houses				
Rent houses	Rent houses	Rent houses	Rent houses	
		Surface houses	Surface houses	
Occupancy overcrouded	Occupancy overcrouded	Occupancy overcrouded	Occupancy overcrouded	Occupancy overcrouded
Room houses	Room houses	Room houses	Room houses	Room houses
Shops	Shops	Shops	Shops	Shops
Total crimes	Total crimes	Total crimes	Total crimes	Total crimes
Emotionally lonely				Emotionally lonely
	Seriously lonely	Seriously lonely	Seriously lonely	Seriously lonely

Figure 6.4: Significant variables and their direction

6.3.2. Most important variables

Eight variables are selected based on the highest P-value from the output discussed in the previous paragraph. The table below presents the results (Table 6.2), a full description of the results can be found in the appendix (Appendix F.2, Table F.2). All mental health outcomes show total crimes in their eight most relevant variables, along with total housing, single person and unemployment. Education also appears in all mental health clusters but varies between the three education levels.

Table 6.2: Most important variables based on P-value

Mental health outcome	Most important coefficients
Anxiety disorder	Payments welfare, secondary education, high education, unemployed, removals arriving single person, total housing, total crimes
Burn out	High education, unemployed, removals arriving, single person, couple without kids, couple with kids, total housing, total crimes
Depression	Income secondary education, unemployed, single person, couple without kids, total housing, total crimes, seriously lonely
Min 1 disorder	Income, payments welfare, high education, unemployed, removals arriving, single person, total housing, total crimes
Not happy	Payments welfare, no basic education, high education, unemployed, removals arriving, single person, total housing, total crimes

6.4. Post-modelling results

This section describes the results from the post modelling phase (Section 5.3.4). Part of this phase is to cluster the predictive values of the most important variables (Section 6.3.2). However, since other cities in the Netherlands do not provide data for many of the most important variables on neighbourhood level, no replica could be studied. Therefore, the predicted values clusters are only presented in the validation section. Thus, this section will only describe the results of the model estimation with the first PCA of each concept.

By taking the first PCA of each of the concepts, an indication can be given about the proportion of the relation between the different concepts and the mental health outcomes. For this step only the significant variables of the concepts for each mental health outcomes are used to derive the first PCA. The amount of variance the first PCA represents of the whole concept is visualized in Appendix G (Figure G.1 till G.5), on average the first PCA explains about 50 percent of the variance. This means that the rest of the information of the concepts is not explained by the variables in the model. The figure below visualizes the result of the PCA regression in the form of a heatmap (figure 6.5). This figure visualizes the P-values for each concepts, a full description of the PCA regression results can be found in the appendix (Appendix F.4, Table F.5). So the darker the colour the stronger the relationship. It shows that the physical and the economic environment, both have a significant and strong relationship with all the mental health outcomes. According to the results, life style is not significant for any of the mental health outcomes. Population characteristics have a strong relation with burn out and not happy and is significant for min 1 disorder. The social environment show a strong relation and significance for Not

happy and anxiety disorder. It does not show any significance for the other mental health outcomes.
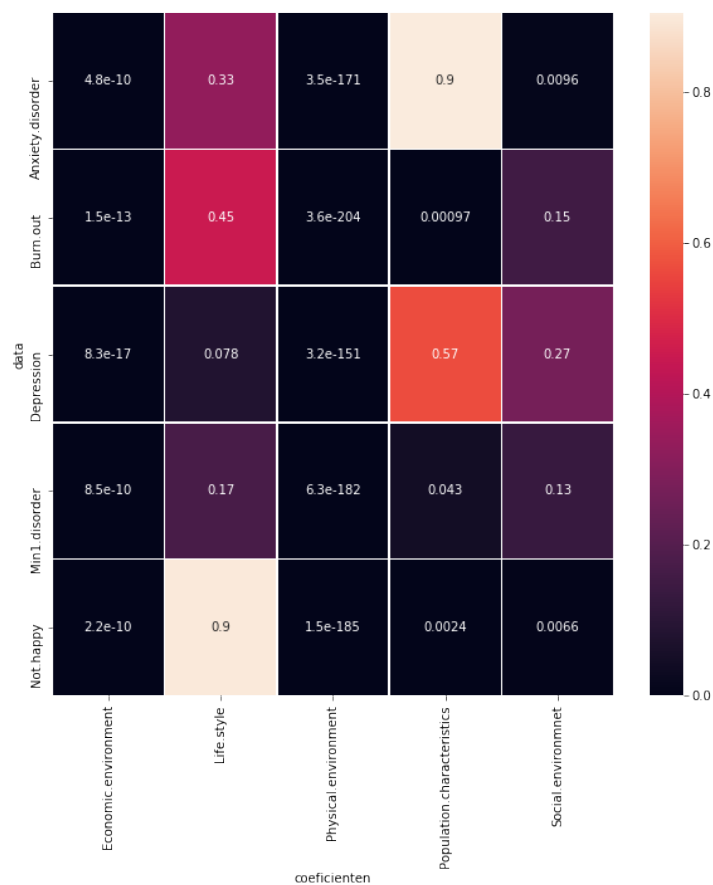
Figure 6.5: Heatmap of the dimension reduced concepts

6.5. Interconnectedness of concepts

As elaborated earlier in this thesis, the interconnectedness of the system makes it hard to develop policies. Therefore, the interconnectedness is analyzed by for a selection of the variables. Total crimes is a variable included the eight most relevant variables of all the mental health outcomes, and is therefore interesting to further investigate. The same goes for Unemployment. High education is variable also often included in the relevant list of the mental health outcomes. Although, no basic education does not appear in any of the eight variable lists, it is always included as a significant variable. No basic education can often been seen as another "class" of society compared to high education, so it would be interesting to also investigate this one. For this step the modelling phase will be repeated on with the outcome variables: unemployed, total crimes, high education and no basic education.

Table F.4 shows the significant variables (Appendix F). In the results can be seen based on theta that the negative binomial is not the right model for no basic education and high

education. Unemployed and total crimes show better results. According to the results unemployed people are related to secondary education. The more people have secondary education in a neighbourhood, the more people are unemployed. More single persons or single parents is also related to more unemployment.They are related to more overcrowded neighbourhoods, with fewer shops and more lonely people. For the total crimes, according to the results, more crimes happen in neighbourhoods where people are more lonely. Besides, Neighbourhoods with more single living people also show more crimes, neighbourhoods with according to the inhabitants have sufficient green, have less crimes. The amount of shops in a neighbourhood is related to a higher amount of crimes. The correlation plot (Appendix C.2, Figure C.1) can also be used to comment on interconnectedness. It shows that the household composition is highly correlated with total housing, shops is highly correlated with total crimes and single parent is highly correlated with unemployed. Besides the correlations between the household compositions show high correlations too.

6.6. Validation

The results presented in the previous section are validated on three aspects. First the fit of the model will be discussed (6.2.1). Next, the model results will be externally validated through generalization (6.2.2). In the final subsection the clusters of the true mental heath outcomes will be compared with the clusters of the predicted mental health outcomes (6.2.2).

6.6.1. Fit of the model

Appendix H gives an indication of the model fit of the negative binomial models. Figure H.1 shows the Pearson residual plots of the holistic 8 variable models for each mental health outcome. None of the plots show a straight line over the zero boundary, this indicates that the model does not show a good fit. The plots for PCA model show an even worse fit, this is probably because the peas explain less variance of the outcomes (Figure H.2). Table H.1 shows the train/test results for the holistic negative binomial models. The proportions between predicted neighbourhood seem similar to the actual proportions.

6.6.2. Generalization of the model results

Section 6.1.2 shows all significant variables per mental health outcomes. In general it shows that Neighbourhoods with an improved living environment is related to improved mental health. A neighbourhood with houses with bigger rooms, more shops, more greenery and less crime is related to neighbourhoods with better mental health outcomes. Remarkable is that all education levels are negatively related to mental health, in which high education has the highest P-value for most of the mental health outcomes. Although negative binomial did not give good results for the education levels, with common sense can be argued that higher educated people have a higher income level and can afford to live in

better neighbourhoods. On the other hand, high educated people might feel higher pressures and work related stressors leading to mental health outcomes. This could also explain why income level is negatively associated with metal health. The literature related to this generalization is described in Chapter 3 and summarized in Table 3.1 (Section 3.3.3).

6.6.3. Comparing the clusters

The first figure in this section represents the clusters of the observed mental health variables within the neighbourhood (Figure 6.6), as already introduced earlier in this section (6.1.1). An overview of the predicted values are included in the appendix (Appendix F.2, Table F.3) The next figure presents the clusters of the predicted mental health values (Figure 6.7). These predicted variables are the result of the model with the eight most significant variables. For clustering the real and predicted value, the same method is used. This is according step one from the data description phase (Section 5.3.2).

The observed mental health neighbourhoods got some high clusters assigned in the lower part of the city centre. Those neighbourhoods did not got assigned with the highest cluster in the predicted clusters plot. When comparing clusters of the higher part of the city, neighbourhoods got either the same cluster or a higher cluster assigned. Though, the left upper neighbourhood show some exceptions where the predicted clusters are lower compared to the observed clusters. The lower part of the city also show higher clusters for the Neighbourhoods of the predicted values compared to the observed values. Although, the neighbourhoods of cluster plot four in the observed cluster plot got cluster three in the predicted clusters plot.

So, the results show different neighbourhoods belonging to different clusters. Some neighbourhoods have similar clusters, some differ one cluster and a few got a complete different cluster assigned. This confirms that there are some shortcomings in the model fit.
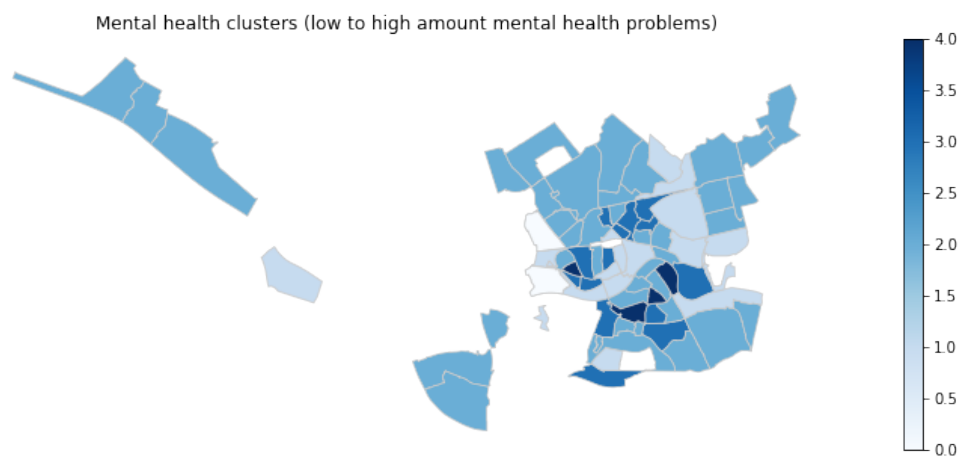
Figure 6.6: Clusters of the observed mental health values
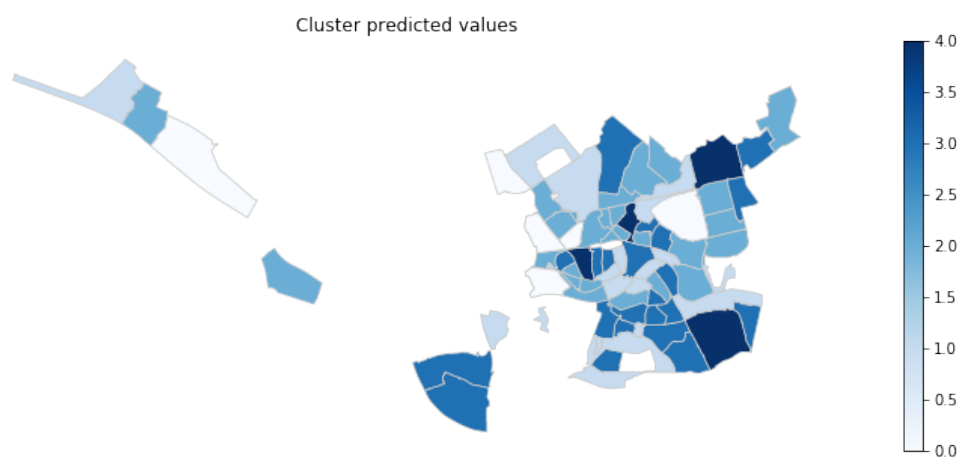
Figure 6.7: Clusters of the predicted mental health values

The political context

This chapter embeds urbanization and mental health in the multi-actor policy-making environment. It analyses current policy-making, the multi-actor environment in which policy-making takes place and identifies improvements for the policy-making process. This chapter argues why policy making should focus on the rational link between research and design and how this will improve urban (mental health) policies. Note that this policy analysis focuses on improving the policy process, not to find applied solutions for reducing urban determinants of mental health. In this chapter, the division of the responsibilities is discussed first, to gain insight in the role of the municipality in developing urban mental health strategies (7.1). Following, the policy trend is discussed to gain insight in different policy-means and the current policy focus (7.2). Based on this trend analysis a means-ends analysis is performed (7.3). Subsequently, the actors are analyzed and their role in shaping the urban environment (7.4). Finally, the last section connects all the previous section by describing the policy challenge (7.5).

7.1. Division of responsibilities in the Netherlands

Municipalities play since January 2015 a bigger role in health and prevention. This decentralization focused on own responsibility, self-reliance, customization of the care, an integral approach, collaboration and cost efficient (Rijksinstituut voor Volksgezondheid en Milieu, n.d.-b). The public health task and the community support provided by municipalities is in the Netherlands regulated by the Wmo and the Wpg. In short, the Wmo covers performance areas that has to be handled by municipalities, under which mental health. The organization of all the public health care is regulated by the Wpg. The role of health insurance companies in prevention is regulated by the Zvw (Forti et al., 2014).

According to the Wpg, the Dutch government has the responsibility to set the budget, while the interpretation and implementation is the responsibility of the municipalities. The freedom for municipalities within the Wpg gives the municipalities opportunities to react on local situations and problems (Rijksinstituut voor Volksgezondheid en Milieu, n.d.-a). Improvements in the urban environment are covered by the Wmo. Social cohesion, accessibility of services, safety and livability are all themes belonging to this healthy urban environment. In contrast to the Wpg, the government does not set the budget. Municipalities have the responsibility to support the public on themes covered by the Wmo. The main aim of the Wmo is to create an integral service on the topics of social support, public health, prevention, education, well-being, housing, job opportunities and income (Rijksinstituut voor Volksgezondheid en Milieu, n.d.-e). The health insurance company has responsibilities considering prevention too. Their responsibilities do not cover the creation of a healthy environment, but consist mainly of education. Where municipalities should create a healthy surrounding, health insurance companies should promote usage of this healthy environment (Rijksinstituut voor Volksgezondheid en Milieu, n.d.-f).

To facilitate prevention policy, the Dutch government developed a four-year prevention cycle. This prevention cycle forms the base for Dutch health policy (Figure 7.1). The first step of the four-year cycle is the Volksgezondheid Toekomst Verkenning (VTV) of the Rijksinstituut voor Volksgezondheid en Milieu (RIVM). This report summarizes the developments of the public health in the Netherlands every four years. Next, the RIVM reports every four years the developments of public health in the Netherlands, based on the VTV. In collaboration with other actors such as other ministries, municipalities and health organization, the RIVM publishes a bill with the national priorities considering public health. In the third step, municipalities draft their local public health bill. This bill is drafted based on the national bill and local epidemic data, advised by health organizations. The last step is supervision on the prevention process, belongs to the responsibility of the Inspectie Gezondheidszorg en Jeugd (IGZ) (Rijksinstituut voor Volksgezondheid en Milieu, n.d.-d).
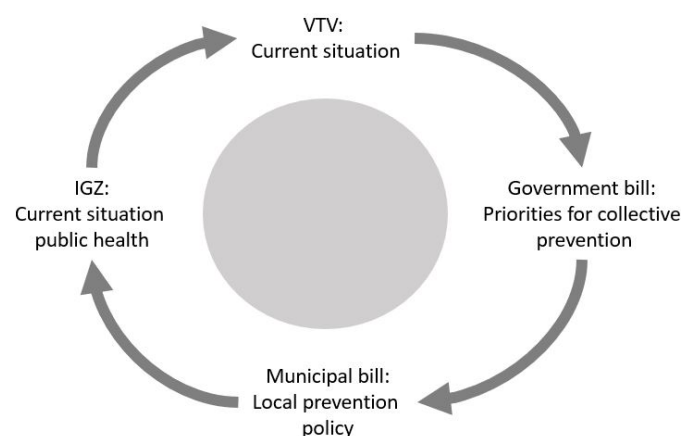
Figure 7.1: Dutch prevention policy cycle

7.2. Policy trends

The policy trends are both analyzed on international and national level. The analysis of international policy regarding preventive mental health actions is formalized by consulting recent documents of the World Health Organization, European Union and the OECD. The result is summarized in the appendix (Appendix I, Table IA.1). This table shows that gathering knowledge and data about mental health and their determinants are subjects coming back in the policy documents of all three organizations. Besides, focusing on collaboration and communities are trends in the documents. Finally inequality is mentioned as a important contributor to mental risks. Considering inequality, international and national organizations have slightly different focus. Where national organizations focus on inequality within a country, international organizations aim at collaboration and reducing inequality between countries (Hansen, de Jong, Groenenwegen, & Ricciardi, 2015).

The Netherlands started a couple years ago with a shift to community based mental health care. Reason for this, is that the Netherlands has about twice the amount of psychiatric hospital beds compared with the European average (Kroneman et al., 2016). Like on international level, more data and knowledge is needed about mental health and their determinants. Other trends in the policy documents elaborate on the demographic component of mental health and the gap between different socio-economic groups in the Netherlands, also corresponding to international trends. The results of the national policy trend analysis can be found in the appendix (Appendix I, table I.2).

The VTV-2018 is the most recent VTV of the RIVM. The VTV-2018 consists of a trend scenario, exploration of themes, options for action and a synthesis. The trend scenario gives predictions for future health trends till 2040 about for example our future perceived health, loneliness and psychological health. The trend scenario analysis predicts that our perceived health will remain the same while loneliness will increase. The future for psychological health, however, is according to the VTV to uncertain to predict (Rijksinstituut voor Volksgezondheid en Milieu, 2018a). One of the topics discussed in the exploration of themes of the VTV-2018, is the living environment design. The theme living environment discusses the future trends of (environmental) health determinants. These are for the VTV-2018 among others the diversifying of the house market, to better adopt to public needs. With this better adopted living environment, the social cohesion in neighbourhoods are expected to improve, because people feel more connected to the surrounding they live in. With the new coming Omgevingswet (expected 2021), health will be included into spatial planning. This new law has the aim to create neighbourhoods better connected to the people living in it (Rijksinstituut voor Volksgezondheid en Milieu, 2018c). One of the options of actions in the VTV-2018 elaborates on the growing pressure people feel, their implications on psychological health and possible actions to mitigate the health impacts (Rijksinstituut voor Volksgezondheid en Milieu, 2018b). In the synthesis of the report emphasizes on degraded neighbourhoods, in which more lower educated people live with a less healthy lifestyle, often having a accumulation of problems (Rijksinstituut

voor Volksgezondheid en Milieu, 2018d).

Next to the VTV report, some bottom-up initiatives started recently in the Netherlands. Within this bottom-up initiatives public and private organizations are collaborating (Nuijen, 2017). One example is the online platform gezondin.nu, in which municipalities and other parties share information and knowledge about reducing health degradation (Pharos en Platform31, n.d.). Another example is allesisgezondheid.nl (AIG). AIG is a bottom-up government initiative that aims to inspire people to be active and healthy in their own environment (Alles is Gezondheid, n.d.). The final example is loketgezondleven.nl which educates professionals and policy-makers to provide a healthy lifestyle and environment for everybody (Rijksinstituut voor Volksgezondheid en Milieu, n.d.-c).

7.3. Means-ends analysis

This sub-section constructs a means-ends diagram from the perspective of municipalities, based on the findings of the policy trend analysis (7.1). The policy trend analysis of organizational and government documents shows a trend in recognizing the importance of evidence-informed policy-making, confirmed by research. Mental health information systems are found to be behind compared to health information systems and policy-makers lack knowledge about the determinants of mental health (Hansen & Nolte, 2018; Kuhlmann et al., 2018; Rosenkötter & Bon-Martens van, 2015). One important action point coming from the policy trend analysis is the reduction of health inequalities. Inequality in the levels of resources people can access are found to play an important roll in creating health degradation (Bjegovic-Mikanovic et al., 2015) and these inequality gaps are still increasing in many places (Ricciardi, 2015). *'People make choices, but not always in the circumstances of their own choosing'* (Maeckelberghe & Mckee, 2015, p.21). The state has the responsibility to provide people with the conditions to make healthy decisions, both on education level as on environmental quality (Maeckelberghe & Mckee, 2015).

The connection Maeckelberghe and Mckee (2015) makes, between the environment and behaviour, is the first division in the means-ends diagram (Figure 7.2). Within the environment environmental inequalities should be reduced, to decrease the 'problem neighbourhoods' and general stressors in the city should be minimized to give people more space in their resilience for mental health problems. Providing people with the resources to live healthy is not enough, they should be educated and nudged to live healthy. Next to the urban environment, people can be influenced by major life events or their own genetic environment in developing mental health disorders. Therefore there must be a good mental health system to treat people with disorders. Central to those improvements, is research and monitoring, providing policy-makers with the information to weigh their dilemmas and make decisions. Although some sections of the documents studied in the policy trend analysis mention the physical determinants of mental health, the majority of the subjects discussed in the policy trend analysis show topics related to improving people's behaviour. This trend is visualized in the figure by the blue highlight.
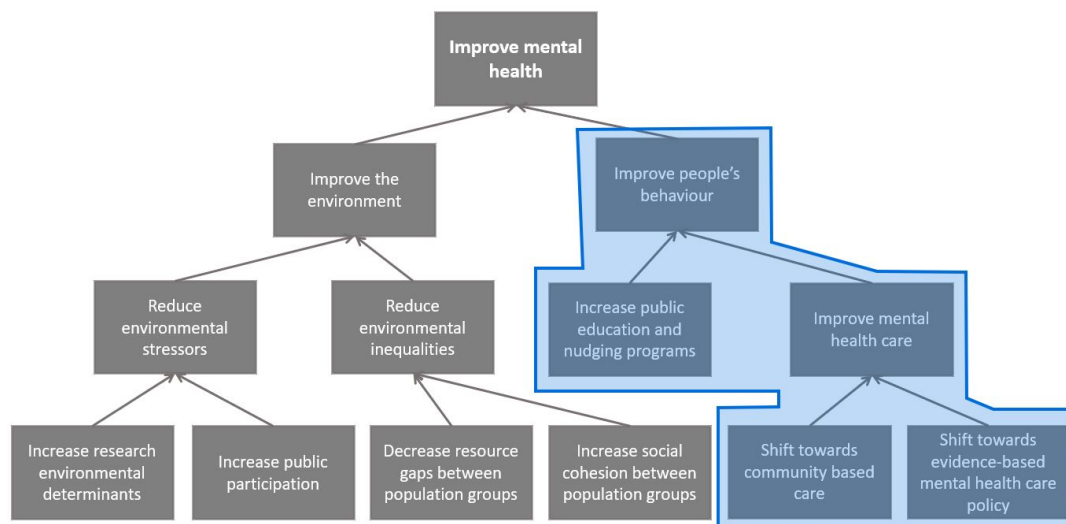
Figure 7.2: Means-ends diagram urban policy-makers

7.4. Actor analysis

Table 7.1 introduces the most important actors involved in the environmental and healthy status within a city. The first actors are governmental bodies and the municipality. Their interests are to develop and maintain the city/country (7.4.1). The second actor is the private sector, whose general interest is profit (7.4.2). The inhabitants of the city also have their influence on the urban environment (7.4.3). Finally, health professionals have the interest to improve health (7.4.4).

Table 7.1: Actor analysis

Actors	General interest	Summary of desired situation
Governmental bodies	Improve the country	Well developed environment on national level for all aspects such as economy, social environment, culture and health
Municipality	Improve the city	Well developed environment on municipal level for all aspects such as economy, social environment, culture and health
Private sector	Make profit	Profitable business in profitable neighbourhoods
Inhabitants	Good living environment	An environment that facilitate their specific needs
Health professionals	A healthy city	Help inhabitants to be healthy or heal

7.4.1. Public sector and organizations

The focus of the public sector is discussed in the policy trend analysis (Section 7.2). The main actors belonging in the public sector and organizations are the World Health Organization, OECD, European Union, Dutch government and Dutch municipalities. All organizations share one interest, containing the well-being of people. Their main difference is within their focus and level of aggregation. The OECD, European Union, Dutch government, Dutch municipalities have a broader definition of well-being than health.

The municipality has the general interest to develop and maintain the city. It has a responsibility in public health. In addition, municipalities have other responsibilities such as economic, cultural and logistic. Improving mental health within a city might conflict with the interest of departments with other responsibilities. For example a logistic department within city has the interest to reduce logistic speed within a city. Public health on the other hand, might want to stimulate exercise and walking, making the roads more pedestrian attractive and decrease the driving speed within a city.

The municipality has different means to influence the concepts as defined in the theoretic framework (Section 3.3.2). Examples of the means municipalities have to influence the concepts can be found in Figure 7.3. The municipality has major influence in the design of the city and therefore has the means to influence the physical environment. The economic environment, social environment and lifestyle can also be influenced by the municipality. The inequality in the economic environment can be for example improved by increasing social welfare or subsidies. The social environment can be improved by building social infrastructure where people have the opportunity to meet and connect. Finally lifestyle can be influenced by education and nudging.
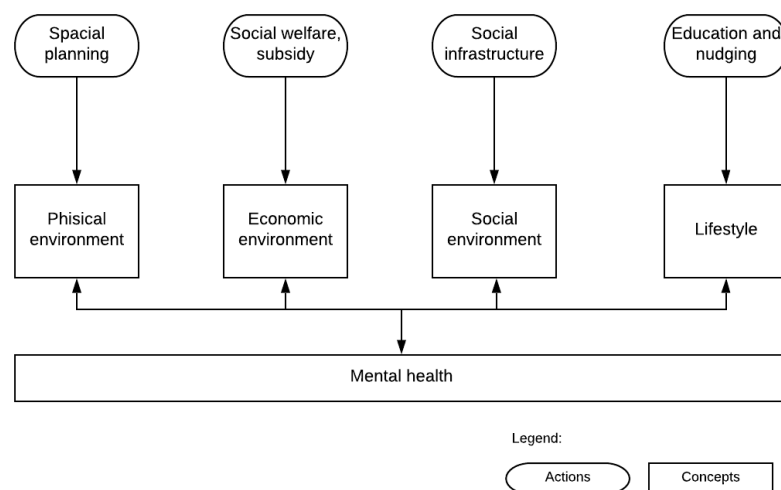
Figure 7.3: Actions of municipality for changing concepts within cities

Furthermore the model showed that the relation between the urban environment mental health is complex. It involves factors from the physical environment, social environment and economic environment. Not only getting an understanding of this system is complex, but often the responsibility of these concepts are scattered throughout the municipality. Table 7.2 introduces the municipal clusters of the case of Rotterdam. Naturally, public health and care is an important municipal factor in developing a healthy environment. However as the model showed, education, exercise, social support, physical environment, economic factors and safety were all relating to mental health. This means that all municipal clusters are involved in urban mental health. Since, the relations are complex and interconnected, the municipality should tackle this problem in which all clusters are collaborating.

Table 7.2: Municipal clusters responsibility source: (Gemeente Rotterdam, n.d.)

Municipal clusters	Responsibilities
Social development	Sport and culture Youth and education Public health and care Social support in the neighbourhood
Urban development	Spacial and economic development Urban design Project management and engineering
City management	Clean city Public works Surveillance and enforcement
Work and income	Income Employment Social employment

7.4.2. Private sector

The private sector has influence on the design and prosperity of the urban environment. The private sector can create employment within the city and can influence its design, construction and maintenance. The real estate companiesF, land owners and project developers have major influence on the layout of a city. They have influence on the refurnishing within a neighbourhood and creation of new buildings within neighbourhoods. Additionally, they influence land use and allocation. Those projects have major impact on the quality and feeling within a neighbourhood. Other examples are the catering industry, are starting new cafes or restaurants. Though, the creation of new cafes, not only the design of a city can improve, it also provide new spaces for people to meet. So, the provision of services is also often influenced by the private sector. Another example of services is the retail sector, opening more shops. The analysis found that neighbourhoods with more shops are related to neighbourhoods with less mental health disorders. However, the main interest of the private sector is profit. Naturally, profits are higher in the more attractive neighbourhood. Thus, the improvements of the private sector often exclude the low-income areas and therefore often comes at the expense of the general equality within the city (Amis et al., 2016).

Figure 7.4, illustrates the influence of the private actor, project developers, on the concepts. Simultaneously, it illustrates the interconnectedness of the concepts. The project developer is involved in the development of a new neighbourhood. This project is currently in the designing phase. The figure shows how the project developer, along with the other actors involved in the neighbourhood development, can influence the lifestyle, economy and social capital within a neighbourhood. The future lifestyle within a new developing neighbourhood can be influenced by for example, stimulating mobility. *Are there attractive routes in the neighbourhoods for running? If people enter their apartment building, do they first see the elevator or the stairs? What is the ratio of sidewalks and cycling lanes compared to car lanes?* These are all questions that possible can influence future lifestyle within a neighbourhood. Another question is whether there will be a place for the less wealthy in this new neighbourhood. This effects the economic environment and equality. The social environment can be influenced by building social infrastructure such as parks. This is not only influenced by the private sector, the public sector has a major impact on the requirements for developing new neighbourhoods.
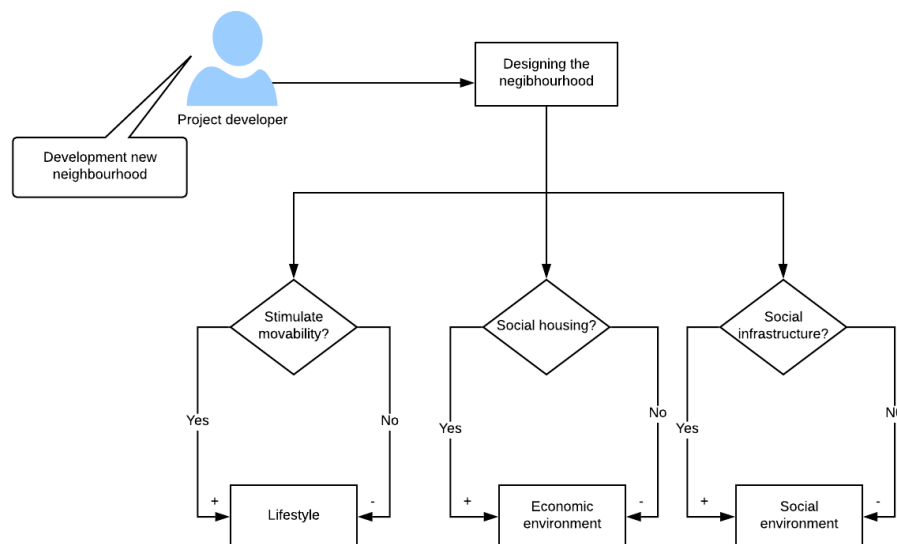
Figure 7.4: Actions of municipality for changing concepts within cities

7.4.3. Public participation

Community participation is a way for policy-makers to understand the public needs and priorities. By involving the public in decision-making, policy actions can be validated. From evidence, policy-makers can retrieve many policy actions to improve mental heath in cities. By involving the public, policy-makers can set priorities complying to the needs of inhabitants. However, many urban policy-makers fail to connect local urban needs to the national developmental agendas and needs (Amis et al., 2016). As a response organizations started to decentralize (Axelsson & Axelsson, 2006). Nevertheless, within public participation is often a gap between the vulnerable and the wealthy in their opportunities to

participate in urban policy-making. The wealthy are more active in public compared to the vulnerable and find their way to urban participation more easy. Inclusive urban governance on low municipal level, may reduce gaps between the vulnerable and the more affluent population both on economical as on health level (Amis et al., 2016). Policy-makers therefore should actively include the vulnerable in the policy-making process.

7.4.4. Health professionals

Health professionals have as general interest to improve people´s health. They are educated to take care for or cure patients. According to the means-ends diagram (Figure 7.2), improving people's mental health can be accomplished through various policy actions. These include reducing environmental stressors, reducing environmental inequalities, increase public education and improve the mental health care. Since health professionals are closely related to the health care, they have improving mental health care as a first priority. Health professionals working in the mental health care, might be confronted with lifestyle and behaviour characteristics that influence their patients mental health. They therefore might stimulate policy-makers to increase public education and nudging programs. However, the relation between the environmental characteristics is more complex, indirect and difficult to identify. Hence, health professionals might be less encouraged to stimulate improvements in the environment and thus, might steer the system into behaviour improvements rather than the environment. However, more research is needed to verify if this is indeed the case.

7.5. The challenge

Municipalities have the policy means to make urban health policies and thereby, improve the urban environment. The public sector becomes increasingly aware of the importance of mental health prevention. It recognizes that pathways towards mental disorders and the contribution of the environment to this are still unclear and this should be further investigated. Although, policy documents do mention environmental determinants of metal health, their focus is still on improving people´s behaviour. To improve people´s behaviour education programs are started and/or mental health is improved (Figure 7.2). This tendency to improve people's behaviour rather than improve the environment could be explained by the lobby of the mental health sector. Mental health patients are treated in the mental health care. Then, it is easier for mental health professionals and policy-makers to predict a decrease of the mental health burden when the mental health care is improved.

Another factor steering policy-making towards the improvement of behaviour side of the means ends diagram is the need for collaboration in order to address environmental determinants of mental health. Collaboration is needed because of the interconnectedness of the concepts that influence mental health outcomes. Section 7.4.1 showed that the significant multi-variate environmental determinants are spread throughout the municipal

organization. In order to develop evidence-based mental health policy-making, this evidence should be spread throughout the organization. In order to incorporate the interconnectedness of the system, a holistic approach should be taken. To approach the policy-making holistically, all municipal clusters have to collaborate in creating a healthy environment. In general, policy-making in collaboration with many actors is more difficult than the policy-making of public health care section of the municipality can develop independently.

However, this section also showed that an inclusive mental health equality throughout the city does not happen naturally. The private sector could improve urban environments, but its focus is usually the urban environments that are profitable. On the other hand, public participation will, without extra incentives, could bring up mainly the voices of the better-off. Combining those two trends, degraded neighbourhoods with a high rate of mental health disorders will remain degraded and unheard. Therefore, active environmental urban health policy-making is needed.

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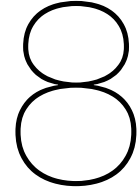
Integral Evidence-Based Policy-Making

The conclusion of the previous chapter described the challenge policy-makers will face implementing urban mental health strategies. Policy-makers should have a basic understanding of the system in order to make adequate policies. In Subsection 2.2.2, evidence-based policy making was defined to be the process of developing policies based on the latest scientific knowledge. When the system operates without evidence, knowledge will reach the municipal bodies. However, the question is whether this knowledge represents the system holistically or only parts of it. Furthermore, the policy trend analysis showed that policy documents focus mainly on improving people's behaviour by either education and nudging programs or better treatments in mental health care (Section 7.2). This creates opportunities for improving mental health by improving the environment in which people live. Section 6.4 showed that the physical environment and the economic environment are highly related to the mental health outcomes, compared to lifestyle and the social environment. The goal of this chapter is to describe how integral evidence-based policy-making can add value to urban mental health strategies. To be able to communicate the added value of integral evidence-based policy-making, this chapter will explain based on a simplified knowledge transferring system.

The first section will describe evidence-based policy-making (8.1). Hereafter, integral policy making will be discussed (8.2).The final section describes how integral evidence policy-making can be implemented (8.3).

8.1. Evidence-based policy-making

"All truths are easy to understands once they are discovered; the point is to discover them"
Galileo Galilei (Moore, 2006)

The term evidence-based policy-making describes the process of policy-making based on recent (scientific) evidence. Within evidence-based policy making, the policy-making process should be informed by evidence rather than directly effecting the goals of policy-making (De Marchi et al., 2016). It facilitates a 'reflective social learning', in which governments are able to create policies interacting with the system as a whole (Martinuzzi & Sedlacko, 2016). Within the evidence-based policy-making process the other aspects of the policy-making process should be taken into account too. These include consultation, stakeholder negotiation and the assessing of options (Head, 2015). Data governance and collaborative governance are the two main pillars behind evidence-based governance (Parycek & Pereira, 2017).

This section describes integral evidence-based policy-making, by first defining knowledge transferring without evidence (8.2.1). This description of the natural system given to be able to communicate the added value of integral evidence-based policy-making. The next section will elaborate further on evidence-based policy-making and in particular the role of data (8.2.2). This section ends with the main limitations and risks of integral evidence-based policy-making (8.3.4).

8.1.1. Knowledge transferring in the natural system

The actor analysis described how actors influence the political context in which urban mental health polices are developed (Section 7.4). The result of this actor analysis is translated into the knowledge that these actors can bring to the municipality (Figure 8.1). The following messages are identified: Mental health practitioners are part of the mental health sector and will are therefore likely to lobby for an improved mental health care system. Additionally, the mental health practitioners are confronted with behaviour of their mental health patients, nudging them to lobby for public mental health education. The wealthy have naturally a stronger voice in public participation compared to the vulnerable. The message of civil society can therefore be defined as improving circumstances for the wealthy. The private sector will provide services based on the needs of the wealthy. Finally the public sector will evaluate the performance of new policies and learn from it. This is not a unidirectional system. Health sectors, civil society and the private sector are also influenced by municipal knowledge or directions the public sector gives.
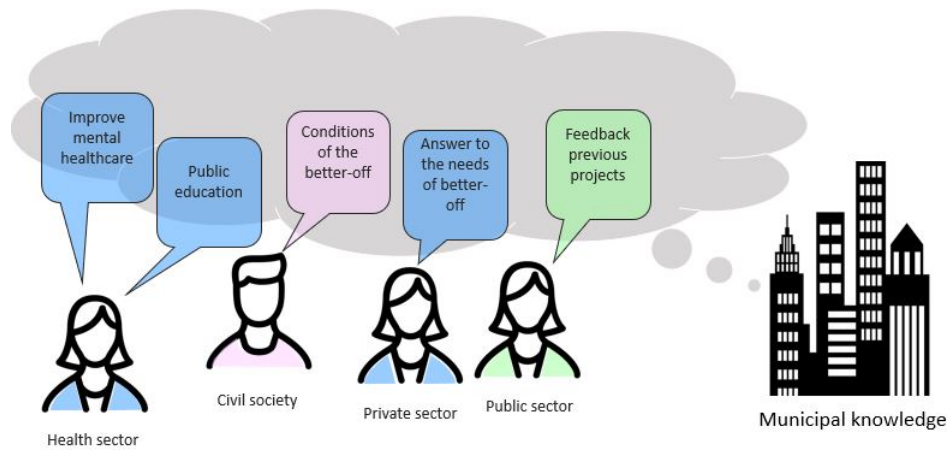
Figure 8.1: Knowledge transfer in natural system

Based on the information that reaches the municipality naturally, the municipality gets informed and policy can be made. Subsequently, policies can be evaluated based on new transferred information to the municipality. For example, health professionals can stimulate the government to make policy to get people to drink less, since drinking is negatively associated with mental health. After policies against drinking are implemented, the effect can be evaluated based on new messages from in this case, the health sector, civil society and private sector. These actors either show that the policies are effective or that some alterations should be made.

With this process of developing policies on incoming knowledge and evaluating them, mental health problems can be mitigated within cities. However, it is not known whether this policy is optimal. *Do all mental health issues reach the municipal body? Are all groups heard in the policy-making process? And are all directions for solutions discovered?* Integral evidence-based policy-making is a way to improve this distribution of knowledge in municipalities.

8.1.2. Role of data

Data modelling can be used by municipalities to gather rational information about the urban mental health system. It can help to identify mental health problems, groups of people in the population with related to similar determinants and directions towards solutions. On top of this, data modelling can be used to instantiate the generic frameworks introduced in the literature study (Section 2.2.2). However, understanding complex challenges like urban mental health, require more than data modelling (Head, 2015). Mixed methods are needed to collect evidence about the cause-effect relationships of urban determinants of mental health and to place them in the political arena (Adam, Steinebach, & Knill, 2018).

The results from Chapter 6 are used to illustrate the role that data can take in evidence-based policy-making. Figure 6.1a (Section 6.1.1), shows that the amount of mental health problems vary across neighbourhoods, suggesting a spatial component to mental health problems. Figure 6.2 showed that mental health has a relation with many

urban variables. Within these results variables show contradicting results, that will be further interpreted in the discussion. Figure 6.3 shows that especially the physical ad the economic variables have a high relation to the mental health outcomes. However, the policy trend analysis (Section 7.2) shows that mental health policy strategies are currently mainly focused on improving people's behaviour.

The value of evidence-based policy-making is visualized in Figure 8.2. Within this figure, the left image shows the natural system, as described in Section 8.1. In this figure knowledge reaches the municipality, however it is unknown if the municipality has knowledge over the full system or only parts of it. The second figure shows evidence-based policy-making based on data modelling. With analyses similar to the analysis of this thesis, but with data on individual level, population groups can be selected with similar determinants of mental health. Those groups are likely to have different needs, and their voices need to be represented within policy-making. Directions for policies can be identified for those population groups. Analysis like in Figure 6.3 can give policy-makers directions and priorities for solutions. Although many variables effect mental health outcomes, some variables might have stronger relations than others. For the efficiency of policy-making it priority must be set on the variables having higher relationships to mental health.

In addition, many variables are interconnected or contradicted, data modelling can help to explain the consequences of this. However, to prevent the policy making process to become 'technocratic' or elitist, mixed methods are needed (Head, 2015). The right image visualizes the mixed method approach. With data modelling a lot of knowledge can be gathered about problems, causes, population groups and policy directions. Nevertheless, qualitative research is needed to really understand the dynamics of complex systems (Head, 2015). The government needs to facilitate citizen engagement and public participation across all identified population groups, they need to negotiate with stakeholders and assess different policy options. So, in order to establish a well distributed and well interpreted knowledge distribution a mixed methods approach is preferred.
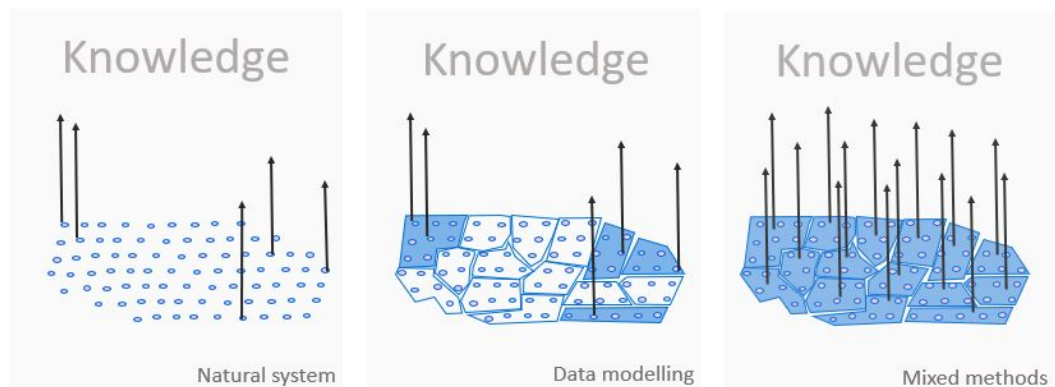
Figure 8.2: Knowledge transfer in natural system

8.1.3. Limitations and risks

The main limitations of evidence-based policy-making from the policy-making side is that it could result 'technocratic' policy-making. Moreover, it does not always lead to democratic improvement and other knowledge must be evaluated as well (Martinuzzi & Sedlacko, 2016). Evidence-based policy-making often is associated with improvement of the efficiency of government agendas instead of leading to innovation and social benefit (Head, 2015). Policy-makers favor specific policy directions, regardless of the evidence. Moreover, evidence can be interpreted and selected in such ways that it can be used to support current agenda's instead of objectively evaluate agenda options and priorities (Head, 2015; Martinuzzi & Sedlacko, 2016). Besides, findings from research are often heterogeneous, unstructured and contradicting. This makes it hard for policy-makers to draw conclusions (Hunter, 2015).

From the researchers side the main limitations are that researchers do not always have sufficient knowledge about the policy-making process. There is a trade-off within independence of the researchers and their connectivity to policy-makers. On one hand research should be conducted independent from policy agenda's to maintain objectivity (Martinuzzi & Sedlacko, 2016). On the other hand, when researchers are more independent, research targets become disconnected from the policy-making process and findings are not sufficiently communicated (Head, 2015). Researchers should have a basic understanding of the policy-process and how their findings could contribute to policy-making. Researchers should also have understating how policy-makers interpreted research in order to communicate their findings, limitations and consequences of those limitations clearly (Bédard & Ouimet, 2016).

8.2. Integral policy-making

Evidence-based policy-making has been found to have major impact on the success of collaborations (Hudson, Hardy, Henwood, & Wistow, 2007). Integration goes further than evidence-based policy-making. In addition to transferring knowledge, integration is about active participation and involvement of actors, with a unification of at least two parties(Vigoda, 2017). With integration certain goals can be achieved, that would not be possible or would have taken more resources if organizations act alone (Bryson, Crosby, & Middletone Stone, 2015; Huxham, 2003). The advantages of integrated government include better sharing of information, a higher resource utilization, and policy making that is more engaged (Parycek & Pereira, 2017). The previous subsection elaborated on the importance to identify groups in the system with high interests. This section focuses on how the municipality should integrate with those external groups. Furthermore, there is need for internal integration, argued in Subsection 7.4.1. For developing an integral policy-making framework, the integration and collaboration framework for public health from Axelsson and Axelsson (2006) is used, complemented by other publications. This section will first introduce integral policy-making (8.2.1). Considering all the forms of integration,

collaboration is chosen as the most applicable form. The next section elaborates on collaboration in more depth (8.2.2). Finally the risks of collaboration are discussed in Section (8.2.3).

8.2.1. Introducing integral policy-making

Environmental complexity led to increasing specialization and then functional differentiation of organizations. Subsequently, this resulted in structural differentiation of organizations and fragmentation of responsibilities. This fragmentation is contradictory to the to the 'holistic' approach to complexity as introduced earlier in this thesis (Section 4.1.4), and the need for integration increased simultaneously (Axelsson & Axelsson, 2006). Integration can be divided into vertical integration and horizontal integration. Integration is vertical when it is structured hierarchically. Horizontal integration takes place when organizations integrate on the same hierarchical level (Axelsson & Axelsson, 2006). The axes of vertical and horizontal integration specify four types of integration. Those types are: co-coordination, co-operation, contracting and collaboration (see Figure 8.3).
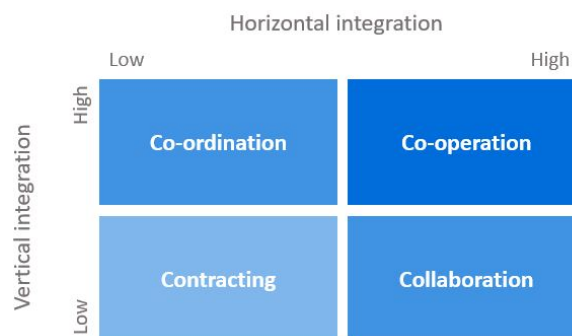
Figure 8.3: Conceptual framework of vertical and horizontal integration (Axelsson & Axelsson, 2006)

According to Axelsson and Axelsson (2006) contracting takes place in competing markets. Within co-ordination, integration is reached by common management hierarchies. The low levels of horizontal integration of co-ordination do not match the interactive and participatory trends within policy-making. Co-operation has both high vertical integration as high horizontal integration and is based on mutual adjustments and voluntary agreements, but implemented with some form of hierarchy. The last form of integration is collaboration. Collaboration can be seen as a "perfect" way of co-operation where common goals are achieved based on the willingness of actors to integrate (Leendertse, Langbroek, Arts, & Nijhuis, 2016), with no or low forms of hierarchy. This results in no actor being fully "leader" or "servant", all actors are considered partners (Vigoda, 2017). Collaboration fits most to public health, since actors often show no form of common hierarchy and policies are mostly approached with interactive through participation and bottom-up initiatives. The next sub-section elaborates on implementation of collaborative integration in more depth.

8.2.2. Collaboration

The functional and structural differentiation in systems along with the fragmentation of responsibility is what drives the need for integration. In order for collaborations to be initiated, the need for integration exists. Furthermore, different sectors should be involved and there should be a willingness to collaborate, which are both connected to need for integration. This because differentiation suggests an increasing amount of involvement of different actors and those actors will be more willing to collaborate if they cannot solve the problem on their own. For collaboration, all actors in the team must have access to relevant information, actors must communicate and a certain level of transparency and trust must be reached (Leendertse et al., 2016).

According to Axelsson and Axelsson (2006), the process of collaboration can be divided into four steps (Figure 8.4). The first phase is forming. If the above described conditions are met, actors are likely to start forming collaborations. In this first phase expectations and constraints must be aligned, the actors must recognize the need to collaborate, a legitimate basis for collaboration must be set and the collaborative capacity must be assessed (Hudson et al., 2007). In the forming phase, management can guide the formation of the collaboration with facilitation of contracts and with stimulating communication among actors (Axelsson & Axelsson, 2006).
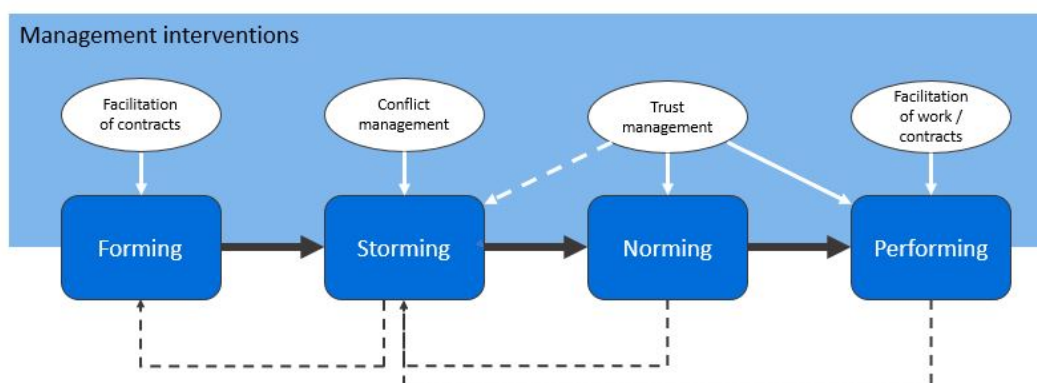
Figure 8.4: Collaboration phases including management interventions (Axelsson & Axelsson, 2006)

The second step is storming. In this step disagreements and conflicting interests will start to show within the collaborating group. A good preparation in the forming stage will already help to reduce conflict in the storming phase. In order to guide the team from the storming to the norming phase, trust must be built between actors (Hudson et al., 2007). Through conflict management, tensions arising in the storming phase can be mitigated.

When those conflicts are resolved, the collaboration will often enter the norming phase. In this phase actors are beginning to trust each other and common culture and values are arising within the team(Hudson et al., 2007). Trust is essential to collaboration, since it stimulates confidence and expected performance within the collaboration, it bonds the actors and develops a sense of goodwill (Crosby, Bryson, & Middleton Stone, 2006).

When this is successfully accomplished the collaboration will start to perform. In this phase the team will work on reaching their goals. In this last phase management guide the process towards the achievement of goals by facilitating among others work and contracts for the team. This process is not linear, in reality teams will often return to the storming or even the forming phase to adopt collaborations to new developments. The structure of collaboration changes over time as the result of the vagueness of membership and complexity of the environment. In collaboration it is often unclear who belongs to the collaboration and in which role, which results from complex collaborative arrangements (Crosby et al., 2006; Huxham, 2003) In order to mitigate the effect of the team falling back into the storming team, fragile relationships must be nurtured and wide organizational ownership must be ensured (Hudson et al., 2007). Lastly, collaborations should be dynamic and adoptive to new changes (Huxham, 2003).

8.2.3. Risks in collaboration

Although collaboration is needed in solving many challenges in complex systems, collaboration itself is complex too. Governments tend to adopt an "optimistic" view on collaboration, especially within cross-sector collaboration. They assume the actors to be rational and therefore automatically open to participate in collaborations if shown that that goals are reached more efficiently in collaboration (Hudson et al., 2007). Additionally, with the assumption of altruism, governments believe organizations will collaborate to purely serve common public good. In reality no organization act purely rational and altruistic and achieving collaborations between organizations is far more complex (Hudson et al., 2007). For organizations, collaboration can be interpreted as a risk. In order to act collaborative, each individual agency must lose freedom. Organizations must invest in developing the relationships, while return of this investment is often uncertain and unclear (Hudson et al., 2007). Actors in collaborative teams often feel competitive and institutional pressure, affecting both the forming stage of the collaboration and the maintaining of collaboration in the remaining stages (Crosby et al., 2006).

Cross-section collaboration often includes many stakeholders. It is in general hard to get all stakeholders involved in the collaboration. Stakeholders are mostly reactive and it is difficult to balance the involvement of stakeholders and time management (Leendertse et al., 2016). Those stakeholders, all differ in interests and organizational structure. Pathways towards goal achievement should meet all those organizational structures and interests of all actors should be satisfied in order to keep the actors involved (Provan, 2009). According to (Huxham, 2003) it is better to avoid collaboration unless potential for collaborative gains are clear for all actors. Hudson et al. (2007) ends the paper with "think big and act small", which could be an approach applicable to integrated evidence-based policy-making.

8.3. Arguing for (integral) evidence-based policy-making

The approach this research takes in investigating urban mental health strategies was initiated by the gap between research on low and high level of aggregation. This thesis positions itself on the middle level of aggregation. Research on low aggregation focuses on single determinant of mental health in depth, the high aggregated frameworks give general descriptions of the system. Research on the middle level of aggregation is needed to provide researchers with the knowledge to address the dilemmas and contradictions in the system. This does not make research on the other levels of aggregation redundant. Low aggregated research might be useful to study the contribution of a variable to mental health outcomes in more depth. A question that could be answered with the study of single variables is: *which population groups benefit of an improvement of this single variable?* High aggregated frameworks are useful for policy-makers. Models of complex systems can lead to complex networks, that are difficult to communicate. High aggregated frameworks on the other hand, can introduce a policy-maker "quickly" to the essence of a system.

In this thesis the determinants of mental health were modelled for the case of Rotterdam. The results confirm interconnectedness, contradiction between variables and the possible existence of groups with different mental health determinants. The analysis also shows that there might be many opportunities in especially the physical and economical environment to improve mental health outcomes. Chapter 7 shows that current policy-makers focus mainly on improving health care and education and nudging programs (Figure 7.2). The argument of the need for more knowledge about the determinants of mental health started in Chapter 2. In Section 7.2 this need was again emphasized. For example the VTV-2018 drafted by the RIVM, showed for all kinds of health topics trends for the upcoming years. However, for the section mental health the VTV-2018 stated that no predictions could be made.

This chapter argued that modelling can help policy-makers to obtain knowledge about the holistic system. In order to illustrate this gain, a "natural system" was described where the municipalities are dependent on the health sector, civil society, private sector and other public sector bodies to transfer knowledge about the system to the municipality. By using mixed methods in evidence-based policy-making the municipality can receive knowledge about the holistic system in a non-technocratic manner.

Section 7.4 showed that the responsibilities for improving the environmental determinants of mental health are fragmented. To address these environmental determinants of mental health integration is needed. Section 8.2 introduced this integral policy-making. It presented different types of integral policy-making and elaborated further on the integrity type: collaboration. From this section, the conclusion is that integrity can be beneficial, but it includes many risks.

The fact the integral policy-making include many risks may let policy-makers decide to take another pathway to improve mental health. However, in order to make an informed decision, policy-makers should have knowledge about the size of the challenge and the role of the environment in this challenge. Therefore, this thesis argues for a mixed methods

approach to mental health policy making. With this evidence-based approach, policy-makers should make well-informed decisions to the level of integrality they will initiate as an approach to the challenge. The trade-off policy-makers face in this is that the maximum utility of an integral approach is higher. However, risk will increase along with the level of integrality. The extent to which policy-makers will take an integral approach should be informed by evidence. For example, the size of the challenge and the size of contribution of the environmental determinant(s) to this challenge should be considered.

8.4. Implementing (integral) evidence-based policy-making

This section describes pathways that should be taking towards (integral) evidence-based policy-making. It thereby connects Chapter 7 and Chapter 8. First, a general implementation is discussed (8.4.1), followed by the implementation of evidence-based policy making for the case of Rotterdam (8.4.2).

8.4.1. General implementation

In order to implement evidence-based policy-making data should be collected in an organized manner. This data should be analyzed and interpreted by skilled people. The policy system needs the capacity to make informed decisions that incorporate the results from evidence. Finally, evaluation and review programs need to be developed to measure performance of the policies (Head, 2015).

Section 8.1.3 described the risks of evidence-based policy-making. To limit these risks evidence-based policy making should be based on mixed methods. Furthermore, the knowledge transferring between policy-makers and researchers should be guided. This analysis on integral evidence-based policy-making is on a generic level. It aims to introduce the reader to integrality and evidence in the context of urban mental health strategies. It illustrates advantages an integral and evidence-based approach can bring to policy-making. Additionally, it also discusses the risks and limitations of those approaches. The generality of this thesis makes it broadly applicable. From this argues the importance of these two approaches for policy-making. However, in order to give recommendations on operational level, more research is needed on integral evidence based policy-making in the context of mental health.

8.4.2. Integral evidence-based policy-making for the case of Rotterdam

In this subsection, the findings of Chapter 7 and 8 in the context of the case of Rotterdam are presented. In 2016, Rotterdam implemented the *Rotterdam healthy city program 2016-2020*, which complies with the European policy framework of 2020 of the World Health Organization for the Regional Office of Europe (Gemeente Rotterdam, 2017; World Health Organization, n.d.-b). These policies mainly focus on education and health care system itself and less on the environmental determinants of health. This corresponds to the findings of Section 7.3. Since the end of the *healthy city program* is approaching, evaluations are expected to start. A policy "window" is available for the policy-making arena of Rotterdam for health (Enserink et al., 2010). This shows an opportunity for re-prioritization and incorporation of focus on the environmental determinants of mental health. An (integral) evidence-based policy-making can be proposed and potentially, initiated.

Section 7.4.1 conducted an analysis of the municipal actor. This analysis described how responsibilities are divided within the municipal body. As can be seen in Table 7.2, the responsibility for public health belongs to the social development cluster. This makes the social development cluster the *problem owner*. However, the social development cluster is not the department within the municipality that has the most power to act. Development of the physical and economic environment belongs to urban development cluster. In order to address the challenge at least there has to be some form of integration between the social development cluster and the urban development cluster. Furthermore, to incorporate evidence in policy-making process there must be a form of integration between research bodies and the municipality. The first step towards integral evidence-based mental health strategies, is to start integrating these actors. In this way, a better understanding of the pathways towards mental health can be established. Additionally the role of urban environment in these pathways should be explored. Subsequently, priorities can be set, new actors can be integrated and directions for new solutions can be assessed.

9

Discussion

This chapter connects and interprets all results of the previous chapters. This will be done by first discussing the results based on the research questions (8.1). The next chapter discusses the challenges for policy-makers to predict the effect of their policies in complex systems (8.2). Subsequently, the results of the analysis will be discussed (8.3). These discussion of the results will be interpreted into the political system (8.4). The chapter ends with a short elaboration on the generalization of the results (8.5).

9.1. Discussion of the research questions

The research questions were presented in the introduction of this thesis. This section discusses first the sub questions, after which the main research question will be discussed. The first research question relates to the relation between separate urban concepts and mental health. During the analysis phase those different concepts were modeled. Results show that factors from all concepts are related to mental health outcomes. The variables belonging to the economic environment that show in significant relation to all mental health outcomes are: income, special welfare, payments welfare, dept assistance, all education levels and unemployment. Lifestyle shows significant relation with all mental health outcomes for excessive drinking. Heavy drinking is significant for burn out and not happy. Sufficiently moving is significant for anxiety disorder and burn out. Finally, control over own life has a significant relation with all mental health outcomes except burn out. Within the population characteristic concepts death and removals arriving, single person household, couple without kids households and couple with kids households show significant relation with all mental health outcomes. The single parent without kids variable shows a significant relation with all mental health outcomes except burn-out. The next concept was the physical environment. Within the physical environment enough

greenery, total housing, value houses, occupancy overcrowded, rooms of houses and shops show significant relations to all mental health outcomes. Ownership houses show only significant relation to anxiety disorder. Rent houses show a significant relation to all mental health outcomes except not happy. Surface of houses have significant relations with depression and minimal one disorder. The final concept modeled is the social environment. Crimes show significant relation to all mental health outcomes. Loneliness is also related to all mental health outcomes, but differ between emotional lonely and seriously lonely. The relation between the single variables covers, thus, many variables. Moreover, it is important to note that the analysis of the variables show that they are highly interconnected.

The second research question relates to the combined models of the urban concepts. The first model is the model that included the eight most important variables. Similar to the previous paragraph, the top eight variables included variables from all five concepts. Crimes, housing, single person household and unemployment were variables included in the top eight variables of all the mental health outcomes. The second combined concepts model, was the regression which modeled the reduced dimension. This model showed that especially the economic and the physical environment is highly related with all mental health outcomes.

The third sub-question referred to the policy challenges. The analysis of the urban concepts showed that the relation between urban characteristics and mental health is complex, in the sense that it is multi-variate, interconnected and brings dilemmas. This argues for future research on the topic of environmental determinants of mental health. Chapter 7 showed that active environmental mental health policy-making is needed. Next to improving behaviour of people, improvement of the environment should be stimulated. Considering the actors that influence the urban environment, if the system would be left alone mainly the better-off neighbourhoods would improve environmental factors, while the vulnerable are left out. Evidence-based policy-making can help counter this tendency. The responsibility for improving the concerning characteristics are scattered through the organization. Chapter 7 also show that responsibilities for the environmental determinants of mental health are fragmented. Therefore an integral approach to the challenge might be needed.

The last sub-question dives deeper into the integral evidence-based policy-making. Chapter 8 argues that municipalities might not receive knowledge of a holistic system without evidence-based policy-making. Government should take an active role in obtaining knowledge. Data can help policy-makers to identify population groups, determinants and directions for solutions. However, mixed-methods are needed to prevent the policy-making process to become technocratic. Furthermore Chapter 7 showed that responsibilities are fragmented. An integral approach could be taken to these challenges. However, Chapter 8 showed that integral policy-making is also complex. Although the maximum gain increases with an integral approach, risk increases along. Policy-makers should make informed decisions about the level of integrality, based on evidence of the characteristics and size of the challenge.

The main research question of this thesis was: *How are mental health problems in urban*

areas influenced by the characteristics of the urban environment?. The answer to this question is that many urban characteristics are related to mental health disorders. These characteristics are interconnected and sometimes contradicting and cover all concepts within a city. This thesis shows investigating the environmental determinants is needed in order to develop sufficient urban mental health strategies. However, in order to define how urban characteristics are defining mental health problems depth, more research is needed. The high level of data aggregation and missing variables makes it hard to draw concrete conclusions from the results. This will be further discussed in the next sections of this chapter.

9.2. The effect of policies

The results show that municipalities and more specifically urban planners do have an influence on the mental health outcomes in their cities. The sufficiency of greening for example in a neighbourhood does have positive relations to the mental health within a neighbourhood. Besides, housing characteristics are influencing mental health, along with shops and overcrowding. Crimes within a city, loneliness, economic degradation are all factors urban policy-makers can influence.

Next to the statement that municipalities can improve the mental health of their citizens, it must be mentioned that improving the mental health of citizens from an environmental perspective is not easy. Complexity was mentioned many times throughout this thesis. This complexity was defined in different aspects of the problem of urbanization and mental health. First, mental health outcomes of an individual is a coming together of genes, life events, behaviour and the environment. Even if an urban environment would be "mental health stressor free" it does not mean people will not develop mental health problems. People might have genetic characteristics, that causing mental health problems regardless of the environment. Additionally, major life events might also cause people to develop mental health problems regardless of the urban environment. Moreover, mental health has a strong time component. Developmental stressors in the past can contribute positively to peoples mental health resilience, while disruptive major live events can on the other hand decrease this resilience. Whether people develop mental health problems is dependent on their personal threshold. Where for some people the improved urban environment will make the difference between reaching this threshold or not, others might develop mental health problems despite their improved environment. Naturally, mental health problems are more than a binary choice of having them or not. Even if people develop mental health problems, their disease burden might be mitigated trough a better living environment.

Besides, the fact that the effect of an improved environment is hard to predict for mental health outcomes, an improved environment is hard to define. First, because the definition of an improved environment differs among individuals. But even more important, an improved environment is a coming together of all urban characteristics. The fact that green influences mental health positively, does not mean that if the municipality plant more green

the urban environment improves significantly so mental health disorders are mitigated. First, because simply planting a park does not guarantee people will use this park. People must feel attractive to the place in order to use it. Moreover, if municipalities create a park in a neighbourhood that will not be used it might trigger a contradicting effect. The shelter of an abandoned park might could attack criminals, who decrease safety and negatively influence mental health in a neighbourhood. Even if a park in the neighbourhood is successful and people will use it, this also does not necessarily has to mean this park improves the environment significant. For example if people live in houses that are in bad condition and that are highly overcrowded, the stressors coming from these conditions might totally crowd out the positive influence of a park. This effect is confirmed by the hierarchy of needs by Maslow (Figure A.1, Appendix A). This theory assumes some hierarchy in the needs of people. For example, if the security needs of a person is not full filled, this person will benefit less from improved social environment. Effects of policies might have contradicting effects. The case of a park increasing criminality already showed this. An example of a dilemma coming from the modelling results the case of shops and criminality. More shops in a neighbourhood has according to the model a positive association with the mental health in a neighbourhood. This seems reasonable since cafeteria and other businesses can bring people together, inspire or have in other ways positive influence on people's mood. Crime on the other hand has negative effect on the mental health, also logical because crimes and unsafely bring up negative emotions and stressors. However, crimes show a high correlation with the amount of shops. This also seems logical since shops are opportunities for criminals to profit from. Nevertheless, this does give the policy maker a dilemma. The policy maker might want to improve the neighbourhood by stimulating business in the neighbourhood. This could have positive effect on peoples mental status within the neighbourhood, but this effect could also be crowed out by the increasing crimes.

In short, urban characteristics are related to the mental health of people. This argues for considering mental health in urban planning. The fact that urban characteristics are interconnected. Priorities in a neighbourhood might differ bases on the coming together of these characteristics and improving one urban characteristic could have negative impact on another, making outcomes of policies hard to predict. This brings up the importance of a holistic approach to investigate the relation between urban characteristics and mental health.

9.3. Discussion of the cluster analysis

This research depended on the availability of open data. Section 6.2 gave a description of the compound data-sets. When comparing the geographical plots in Figure 6.1, lifestyle shows the least similarities with the mental health outcomes. The physical environment, shows the most similarities with the mental health outcomes. This suggests that lifestyle has a weaker relation with mental health compared to the physical environment. In general, the concepts have more "worse" performing neighbourhoods than the mental health outcomes, this is

confirmed in Figure 6.2. The cluster analysis showed that the mental health outcomes are relatively similar within the clusters. This is confirmed by the significant modelling outcomes. Many of the significant variables have this significant relationship with all mental health outcomes. Moreover, these variables always have either a positive or a negative relationship to all mental health outcomes. This indicates that there are neighbourhoods that have a "bad" relation to mental heath outcomes, while other neighbourhoods relate "good" to mental health outcomes. Moreover, this indicates that the determinants the mental health outcomes could be similar.

Analyzing the population characteristics, cluster three represents high death, relatively high single person and low birth, removals arriving, single parents, couple without kids and couple with kids. This could indicate that the city of Rotterdam has "elderly neighbourhoods", where elderly live alone in the same house for over long time periods. Neighbourhoods where the removals arriving is higher are where more single persons live and couples without kids. This could indicate a "young neighbourhoods", were people live before they start a family. The other clusters show a high birth and relatively high couple with kids and single parents. Those clusters have similar values for the variables and could indicate "child friendly neighbourhoods".

Considering the lifestyle neighbourhood clusters, there are neighbourhoods performing "bad" on lifestyle. These neighbourhoods have high excessive and heavy drinking, low exercise standard, moves sufficiently and people have low control over their own life. Next to those neighbourhoods, there are "good lifestyle" neighbourhoods that score low on drinking an high on exercising. Moreover, the cluster indicates neighbourhoods that score high on both drinking and exercising and clusters that perform average on drinking and exercising. High drinking and exercising could indicate the "young neighbourhoods", since young people could be associated with both exercising and going out.

Notable in the social environment clusters is that total crimes has a high value in only in one cluster. This could indicate neighbourhoods in which people do connect, so a high social cohesion. On the other hand people in these neighbourhoods might possess less resources and are therefor more inclined to commit crimes.

The next environment in the cluster analysis was the physical environment. For the clusters that represents neighbourhoods consisting of more bought than rental houses, there is a neighbourhood cluster with low value houses and a neighbourhood cluster with high value houses. The neighbourhood with the low value of the houses has a slightly less value for less greenery, the houses have less surface, more overcrowded and has less shops. This trend is also in the neighbourhood clusters which have more rental houses compared to bought houses. This can indicate is spacial inequality. In this inequality people with a higher income can afford a house with a higher value and therefore live in "better" neighbourhoods.

This spacial inequality can also be concluded form the clustering of the final environment. This clustering indicates that there are neighbourhoods with lower income, lower education

level, higher special welfare, payments welfare and unemployment. Other neighbourhoods have the exact opposite characteristics. This implicates a spacial distribution of economic well-being. Furthermore, it indicates the existence homogeneous neighbourhoods. Finally, there is a cluster with low income, low special welfare and relatively low unemployment. This could indicate the "elderly neighbourhoods".

9.4. Discussion of the analysis results

In the models, the data explained only about one third of the deviance. This suggests that variables influencing the mental health are missing. Some variables that are not included but suspected to effect mental health are for example age, ethnicity and religion. Those variables could explain some of the contradicting results. One outcome that contradicted expectations is the that excessive drinking has positive effect on mental health. An explanation for this could be the amount of students in Rotterdam, and their drinking culture. The cluster analysis showed that these "young neighbourhoods" could exist in the city of Rotterdam. An other explanation could be that excessive drinkers could lose their connection to reality and are unable to identify their mental problems. However, the outcomes of the model do not provide sufficient information in order to be able to identify the cause of this contradiction with the expectation. Variables that could have helped identify nature of excessive drinking are age and amount of students. Another contradicting result compared to prior expectations is that deaths positively influence mental health outcomes. In general one could expect that death would increase stressors in the surrounding of the one that passed away. A variable that could explain the positive effect of deaths is that a neighbourhood might have more elderly people. Although elderly are more lonely, they have less mental health disorders especially considering anxiety disorder and burn out. The cluster analysis suggests those "elderly neighbourhoods" exists. Again in order to identify this age should be included in the model.

Another contradiction that could be found in the results is that high education appears to have the highest association with high mental disorder rated neighbourhoods, compared to the other education levels. High education is in general associated with a higher level of income, a higher surface of the houses and are more often house owners. Both increasing income and house surface show a negative relation with mental health outcomes. The variable higher amount of rental houses is positively associated with mental health outcomes confirming the ownership expectation. However, higher education should also be associated with a higher value of the houses, higher amount of rooms, lower amount of overcrowding and lower amount of total housing within a neighbourhood. This because, they earn more so can afford to live in a house with a higher value. Higher value of houses is associated with the the amount of rooms, which should be higher for high educated people. Besides, they can afford to live in less overcrowded places. Considering the negative relation with higher education effect mental health outcomes negatively, one could expect that higher value of the houses, higher amount of rooms and lower amount of overcrowding would be negatively associated with mental health outcomes. However, the results show

the opposite. This could indicate that there are two or more mental health clusters among the population. One group of high educated inhabitants having high mental disorders and a group of low educated people, living in degraded neighbourhoods. The mental health problems of these different groups might have different causes, leading to different policy actions. Where high educated people might develop mental orders due to high expectations and high work load, while people with low income develop mental disorders because of their degraded environment and financial stressors. However this cannot be further investigated with the neighbourhood level open data. Data on individual level is needed in order to investigate mental health outcomes conditional to education level.

The insignificance of social cohesion is an next outcome diverging from expectations. This, could be explained by that social cohesion variable is summarizing a variety of variables. As introduces in the theoretical framework social cohesion can be measured by many variables. These are for example the social infrastructure, social recovery capital, social bridging capital and social binding capital. They could all effect mental health differently. On top of this, they show an ordinal range of three. Giving not much variation through the data-set. Another variable of which the meaning now is debatable is total housing. Considering that population is assumed to be an offset variable, the question might arise if total housing would have offset characteristics too. Since, total housing also represents the amount of observations. However, this representation is more indirect than the population. How the results are interpreted now, the total housing gives an indication of the density of the neighbourhood. To represent this characteristic more accurate, the total housing could be divided by the surface in a neighbourhood for future research.

A critical note is that the model seems not to fit the data very well. This might be the result of missing variables such as age, the high correlation among the variables and the small number of neighbourhoods. It is recommended to perform further research, namely to fit these models on larger data-sets by either increasing the number of neighbourhoods or increasing the data-set by aggregation on lower level. Besides, the data-set size should be increased by the number of variables.

9.5. The political system

The previous section in this discussion, suggested that at least two mental health clusters can be defined within a city. Those clusters concern the better-off with mental disorders and the vulnerable with mental disorders. Combining this with the natural tendency of the urban system to adjust for the needs of the better-off, groups of vulnerable people with mental disorders are risked to be left out. An example of this might be that municipalities develop greenery and parks throughout the city, giving the inhabits space to process their daily stressors. The better-off might be able to process their demanding daily life, the vulnerable might also find some mitigation in those new parks. However, if they live in overcrowded degraded houses, having financial debt or don't feel accepted in society the effect of a new park might be negligible compared to the effect of for example improved

houses. This adds to the argument that the vulnerable should be actively included in policy-making.

For the identification of unrepresented groups, evidence-based policy-making is useful. Instead that the municipalities only receive knowledge from actors, through modelling more rational knowledge can be retrieved, groups can be identified and an inclusive set of actors can be stimulated to participate in the policy-making process. Furthermore, through evidence-based policy-making the environmental determinants of mental health should be identified and researched, in order for policy-makers to set well-informed priorities. Chapter 7 showed that the responsibilities of the environmental determinants of mental health are fragmented. This, next to the fact that the system is interconnected argues for an integral approach to mental health policy-making. Although an integral approach increases the maximum gain, it introduces more risks. There are different forms of integral policy-making and policy-makers should make well-informed decisions about if and till what extend an integral approach should be taken, based on the characteristics of the challenge.

Currently policy-making focuses mainly on education and improvement of the mental health systems. In chapter 7 this trend was argued from two perspectives. The first perspective is that the relation of the health care system and behaviour to the mental health outcomes is more direct for the mental health professionals. As a result this message will be communicated to the municipalities. The other perspective is from the municipality. For improvements in mental health care and education, collaboration should be started. However, collaborations for these means require less cross-sectoral approaches and are therefore less complex. The system and actor analysis are based on the trend analysis. More research is needed to validate whether the system indeed follows the natural tendencies as described in Chapter 7.

Furthermore, the objective of this thesis was to research urbanization and health from theoretical perspective, data modelling and the policy arena. As a result this thesis takes a holistic approach to the challenge. However, more in depth research should be done in order to give operational recommendations.

In 2017 the municipality published a report on the healthy city program. This program is ending in 2020. This upcoming end implies that the municipality and the involved actors will have to evaluate the program in the near future based on their set goals. The healthy city program focuses on the behaviour side of the means ends diagram presented in Section 7.3. Thus, there is the opportunity for Rotterdam to improve their performance of mental health strategies on the environment aspect. This thesis argues for a shift of focus in which the environment is also incorporated. The end of the healthy city program, can be the beginning of this new focus to address the challenge of mental health in a holistic manner. This thesis shows that there is a spacial component to mental health problems and that the mental health outcomes are related to the multivariate and interconnected environmental concepts. In order to approach the challenge holistic, "rational" knowledge should be gathered and if necessary collaborations should be initiated.

9.6. Generalization

The generalization is divided into two subsections. The first subsection describes the generalization of the theoretical framework developed in this thesis (9.6.1). The next section describes the generalization for the case study Rotterdam.

9.6.1. Generalization of the framework

In this thesis the first step towards the modelling is to set a theoretical basis. For this a theoretical framework is developed Section 3.3. This theoretical framework forms the assumption, on which the system is modelled. Section 2.2.3 and Appendix A gives descriptions of frameworks described in the literature.

The first framework described in Appendix A was the framework of the hierarchy of needs by Maslow. This framework assumes for example that people will start wanting to comply to security needs when their basic biological / physiological needs are fulfilled. This hierarchy in needs cannot be directly found in the theoretical framework developed in Chapter 3. Nevertheless, the results in Chapter 6 does suggests that people in different circumstances have different needs, as discussed in Section 9.4.

The next framework discussed in Appendix A is the framework of Nijkamp et al. (1998). The interconnection that this framework describes between the social environment, physical environment and economic environment is part of the framework in Section 3.3.

Shafer et al. (2000) shows an interconnection between community, environment and economics which is similar to the concepts defined in the Chapter 3 framework. Moreover, Shafer et al. (2000) states in the corresponding paper that this framework is based on the assumption that there is an interconnection between the social, economic and physical environment. Furthermore, Shafer et al. (2000) places quality of life as the concept, that is the result of the interconnection between community, environment and economics. The framework of chapter 3 places behaviour as this central concept, in which mental health is defined. Mental health has a major impact on quality of life.

The next framework of Blum, include mental health (1974). In this framework mental health is defined between behaviour and the mental health care services, interrelated with the ecological balance and the cultural system. The framework of Chapter 3 includes mental health to be a part of behaviour. The mental health care service, however is not included in the framework of this thesis. Within this framework mental health care can be seen as an "external factor" influencing behaviour.

The fifth framework discussed in Appendix A is the framework of RIVM (2000). It defines health to be influenced by environmental quality and social quality. These environments are included in the framework of Chapter 3. The RIVM framework does, in contradiction to the Chapter 3 framework, not include the economic environment.

The last framework in Appendix A is the framework of Leidelmeijer and Kamp (2003) and is most related to the Chapter 3 framework. Both frameworks include personal and environmental components and both frameworks divide concepts into measurable variables. However, the framework of Leidelmeijer and Kamp (2003) is divided in more concepts. This makes it more derailed, but on the other hand it makes it more difficult to interpreted, see connections and model.

9.6.2. Generalization case results Rotterdam

This research contributed to investigate the relation between urban characteristics and mental health. Urbanization and a growing mental health burden are trends all over the world. This research investigated the problem taking the city of Rotterdam as a case. *What do the results implicate about urbanization and mental health in general?* Naturally, urban characteristics, social norms, culture, climate and the economic distribution varies throughout cities all having their impact in how mental problems develop. In order to identify priorities in other cities replicas should be studied. However, the findings in this study could be similar to other Dutch and Nordic cities, such as the Hague, Utrecht, Amsterdam, Copenhagen and Berlin. Also here, replica studies should be done to investigate if the city plays a similar role in the development of mental health problems. Finally, the model gives similar results to literature (Section 6.6.2).

10

Conclusion

This conclusion will first describe the (policy) recommendations this thesis emphasized (10.1). Subsequently, the scientific contribution of this thesis will be discussed (10.2).

10.1. Recommendations

This thesis shows that the relation between urban characteristics and mental health outcomes is complex, interconnected and sometimes contradicting. Variables from a variety of urban areas are related to mental health outcomes. The relation between the urban environment and mental health outcomes suggests that environmental mental health policies are needed. The interconnectedness and contradiction among variables suggest that the high aggregated frameworks are not enough to develop sufficient strategies. Moreover, the urban system naturally tends to improve the environment of the better-off, while leaving the vulnerable out. Integral Evidence-based mental health policy-making is needed to develop well-considered urban policies. These evidence-based mental health policies should include knowledge from the holistic system, among which the vulnerable. Moreover, knowledge of mental health pathways and the role of the environment, should be implemented in the full municipal organization. This because, responsibilities for the urban characteristics are spread through the organization. A holistic approach should be taken in order to develop urban mental health strategies that incorporates interconnectedness. This suggests that municipal clusters must collaborate to develop the strategies. Integral approaches to policy-making are in general challenging. The organizational challenge combined with the lack of knowledge about environmental determinants of health might be an explanation why currently focus on the improvement in the behaviour of people rather than improvements in the environment.

10.2. Scientific contribution

The second chapter of this thesis identified gap in scientific mental health research. This gap is between high aggregated policy frameworks and univariate or limited variate scientific research. In order to incorporate the complexity of the system a holistic approach should be taken. In chapter 3 an theoretical framework is developed as the basis for modelling. The framework is developed based on literature and earlier developed frameworks. This framework can be used to conduct studies about the urban environment and mental health for other cities. Furthermore, the predicted values of the holistic model (step 2 of the post-modelling phase) can be used to predict mental health outcomes within cities based on the urban characteristics.

The previous conclusions are drawn based on the analysis conducted in this thesis. For analyzing urbanization and mental health an exploratory deductive approach was used. The system is analyzed by first developing a theoretical framework, which visualizes the interaction between the genetic environment, resilience, life style, mental health status, economic environment, social environment and physical environment. This theoretical framework formed the basis of the block-wise variable reduction using negative binomial regression. The result of the modeling is a set of significant variables influencing the five mental health disorders: anxiety disorder, burn out, depression, minimal 1 disorder and not happy. Thereafter the results were placed in the political environment.

This thesis showed that environmental mental health strategies are necessarily in urban policy-making. However, the results do not provide enough insight to draw direct conclusions about how urban characteristics are influencing mental health. The coefficients explain about one third of the deviance in the outcome variables. This suggests that characteristics are missing in the model. Variables that should be included in future research are among others age, religion and ethnicity. On top of this, the data is aggregated on neighbourhood level. To identify population groups vulnerable for mental health conditional outcome variables should be modelled. For this data on individual level should be used. The results of other Nordic cities are expected to be similar to the results of the city of Rotterdam. However, this should by validated by conducting similar studies in those cities.

This thesis showed that indeed research on middle level of aggregation is needed to inform policy-makers. Research should investigate the multivariate system in depth. For this the system should be modelled holistic. Based on the results first relations between urban characteristics and mental health were identified. However, further research is needed to draw direct conclusions about the how the urban environment relates to mental health outcomes. This research should have excess to an extended data-set, that representing both more cases and more variables. These cases could be more neighbourhood, but data on the individual level is preferred.

A
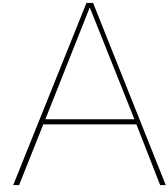
Quality of life frameworks

For the analysis of the quality of life frameworks relevant for urban mental health strategies are selected from the paper of Leidelmeijer and Kamp (2003). This Appendix describes six frameworks related to human needs, quality of life and the environment.

The theory of Maslow assumes that the needs of people are hierarchical organized (Figure A.1). According to Maslow, the first needs of people are the physiological needs a humans have in order to survive. The second layer represents aspects related to safety. If people feel safe, they start to want to comply to their social needs. The last layer are the ego needs, which represents self-actualization. This could for example be that a writer must write and a athlete must sport. When realizing the layer of needs, the first layer has limited options and is similar among people. However, the higher the layer the more options and the more personal specific are the needs (Leidelmeijer & Kamp, 2003).

Self-actualization/fulfilment

Ego needs

Social needs

Security needs

Biological / physiological needs
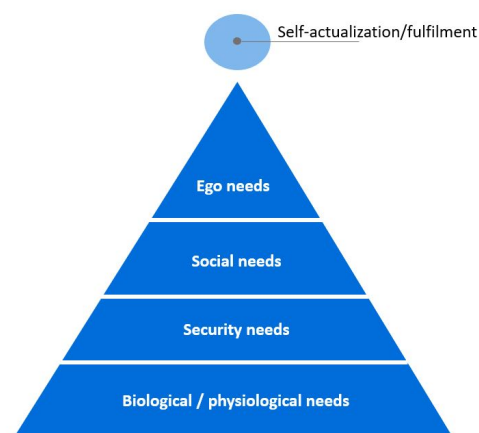
Figure A.1: Hierarchy of needs by Maslow based on Leidelmeijer and Kamp (2003)

The framework presented in the figure below (Figure A.2) informs policy-makers about the wide variety of urban issues that arise in the different or combinations of urban environment. This framework has the aim to help producing more sustainable urban policy. In this frame work all three environments bring advantages and disadvantages to cities and the because of the interconnections of these environments they cannot be considered alone in urban policy-making. (Nijkamp et al., 1998)
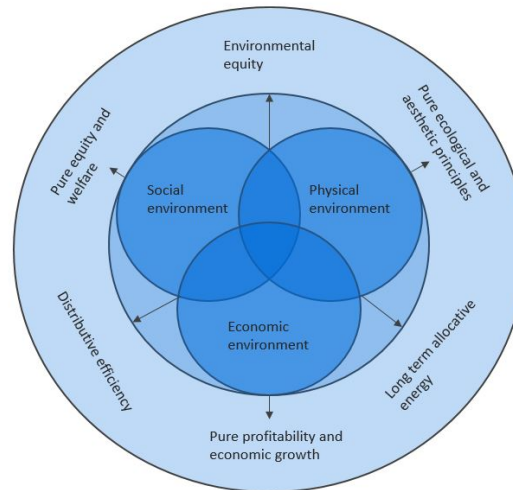
Figure A.2: The locus of sustainability principles and policies (Nijkamp et al., 1998), cited by Leidelmeijer and Kamp (2003)

The framework developed in Shafer et al. (2000) looks at the urban environment from the individual perspective rather than the urban sustainability perspective of the framework of Nijkamp et al. (1998). This framework was developed with the aim to communicate the basic relationships between the different components to space. Those components of space are defined to be the physical, social and economic environment. On top of this, the model defines quality of life to be an interconnection between community, environmental and economic qualities. Similar to the framework of Nijkamp et al. (1998), this framework emphasizes that a good environment cannot be achieved by focusing on one component alone (Shafer et al., 2000).
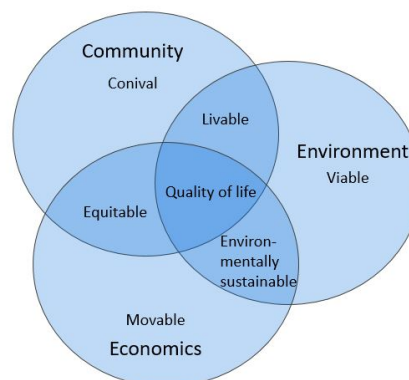
Figure A.3: Quality of life framework (Shafer et al., 2000), cited by Leidelmeijer and Kamp (2003)

One framework that is related centered to public health is the framework of Blum (1974), cited by Leidelmeijer and Kamp (2003). In this framework health in a broad sense is defined as a result of the influences of genes, quality of health care, behaviour and the quality of the social and physical environment (Leidelmeijer & Kamp, 2003)
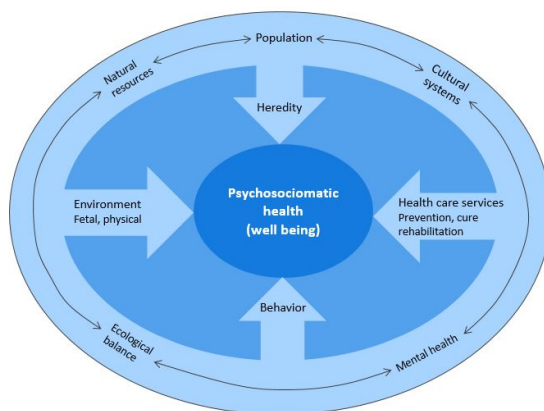
Figure A.4: Determinants of health (Blum, 1974), cited by Leidelmeijer and Kamp (2003)

The RIVM (2000), cited by Leidelmeijer and Kamp (2003) developed a framework of the daily living environment and health, in which quality of life is central. This model conceptualizes subjective perspective of the environment and their connection to quality of life. This perception does also have a relation with personal characteristics, lifestyle , health and general societal context. The framework gives an overview of the determinants of quality of life on a high level of abstraction. This because, the framework does not indicate how the aspects relate to each other. The RIVM does distinguish health and daily life environment in this framework and the subjective and objective subgroups of these (Leidelmeijer & Kamp, 2003)
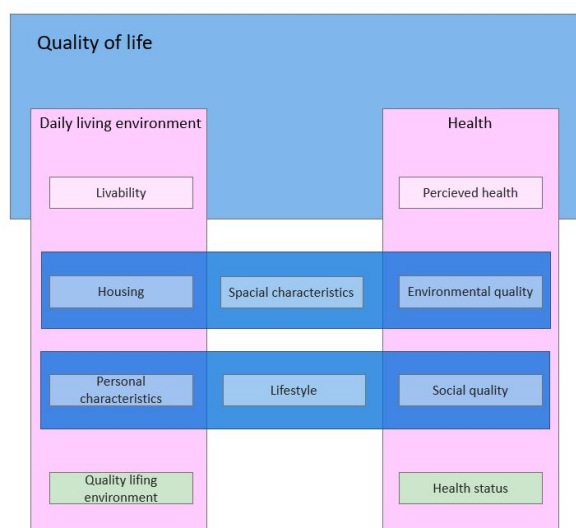
Figure A.5: Quality of life (RIVM, 2000), cited by Leidelmeijer and Kamp (2003)

Finally Leidelmeijer and Kamp (2003) also developed a framework about the dimensions of livability. This framework is the characteristics of humans and the environment which determine whether they consider the living environment livable. This framework is based on literature study. And represents eleven dimensions of livability, supplemented with variables that are mentioned most in literature (Leidelmeijer & Kamp, 2003). With this, in contradiction to the other frameworks, Leidelmeijer and Kamp (2003) presents a framework which include measurable variables.
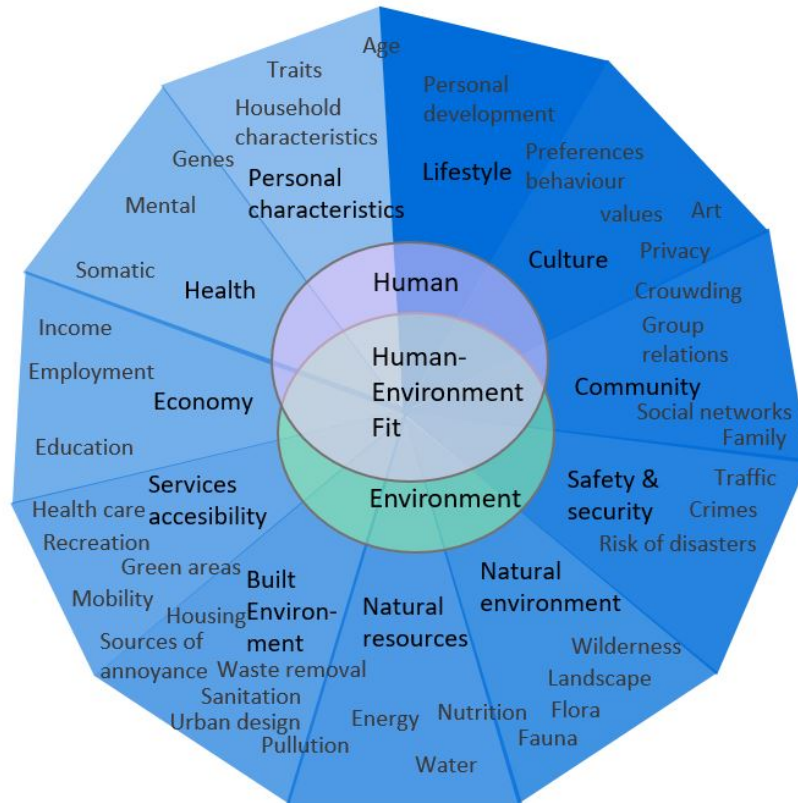
Figure A.6: Dimensions of livability (Leidelmeijer & Kamp, 2003)

B

Data dictionary

This appendix presents the data dictionary used for modelling the relation between urban characteristics and mental health. The first table presents the unprocessed data (Table B.1). It describes the data per variable, to which concept this variable belongs, the year this variable presents, the source and the population group if applicable. The second table describes the data after processing (Table B.2). This table presents the variable, the variable name used in the modelling, the concept to which this variable belongs, the data type and the measurement type.

Table B.1: Data dictionary before data processing

Concept	Variable	Year	Source	Population Group
Geometry	Neighbourhoods Rotterdam	2016	CBS	-
Population Characteristics	Households	2016	Rotterdam Buurtmonitor	-
	Population	2016	Rotterdam Buurtmonitor	-
	Birth	2016	Rotterdam Buurtmonitor	-
	Death	2016	Rotterdam Buurtmonitor	-
	Removals leaving	2016	Rotterdam Buurtmonitor	-
	Removals arriving	2016	Rotterdam Buurtmonitor	-
Economic environment	No education level	2016	Rotterdam Gezondheidsmonitor	Age 15 till 75
	Secondary education level	2016	Rotterdam Gezondheidsmonitor	Age 15 till 75
	Completed bacholor or master	2016	Rotterdam Gezondheidsmonitor	Age 15 till 75
	Unemployed	2016	Rotterdam Gezondheidsmonitor	Age 19 till 65
	Income	2014	Rotterdam Buurtmonitor	-
	Financial difficulty	2016	Rotterdam Gezondheidsmonitor	Age 19 and older
	Payments welfare	2016	Rotterdam Buurtmonitor	-

Table B.1 – continued from previous page

Concept	Variable	Year	Source	Population Group
	Clients debt assistance	2016	Rotterdam Buurtmonitor	-
Social environment	Social cohesion not diverging from average in region	2016	Rotterdam Gezondheidsmonitor	Age 19 till 65
	Social cohesion lower than average in region	2016	Rotterdam Gezondheidsmonitor	Age 19 till 65
	Social cohesion higher than avarage in region	2016	Rotterdam Gezondheidsmonitor	Age 19 till 65
	Total crimes	2016	Rotterdam Buurtmonitor	-
	Moderate to very lonely	2016	Rotterdam Gezondheidsmonitor	Age 19 and older
	Seriously lonely	2016	Rotterdam Gezondheidsmonitor	Age 19 and older
	Emotional lonely	2016	Rotterdam Gezondheidsmonitor	Age 19 and older
	Social lonely	2016	Rotterdam Gezondheidsmonitor	Age 19 and older
Life style	Smoking	2016	Rotterdam Gezondheidsmonitor	
	Moves sufficiently (own judgment)	2016	Rotterdam Gezondheidsmonitor	Age 19 and older
	Complies with exercise standard (NNGB)	2016	Rotterdam Gezondheidsmonitor	Age 19 till 65
	Excessive drinker	2016	Rotterdam Gezondheidsmonitor	Age 19 and older
	Heavy drinker	2016	Rotterdam Gezondheidsmonitor	Age 19 and older
	Enough control over own life	2016	Rotterdam Gezondheidsmonitor	Age 19 and older
	Unable to handle financial matters (theirselves)	2016	Rotterdam Gezondheidsmonitor	Age 19 and older
	Thinks green is important	2016	Rotterdam Gezondheidsmonitor	Age 19 and older
Physical environment	Inhabited addresses	2016	Rotterdam Buurtmonitor	-
	Shops	2016	Rotterdam Buurtmonitor	-
	Total housing	2014	Rotterdam Buurtmonitor	-
	Built before 1945	2014	Rotterdam Buurtmonitor	-
	Built between 1945 and 1959	2014	Rotterdam Buurtmonitor	-
	Built between 1960 and 1969	2014	Rotterdam Buurtmonitor	-
	Built between 1970 and 1979	2014	Rotterdam Buurtmonitor	-
	Built between 1980 and 1989	2014	Rotterdam Buurtmonitor	-
	Built between 1990 and 1999	2014	Rotterdam Buurtmonitor	-
	Built between 2000 and 2009	2014	Rotterdam Buurtmonitor	-
	Built between 2010 and present	2014	Rotterdam Buurtmonitor	-
	Unknown built year	2014	Rotterdam Buurtmonitor	-
	Value from 1 till 50,000	2014	Rotterdam Buurtmonitor	-
	Value from 50,000 till 100,000	2014	Rotterdam Buurtmonitor	-
	Value from 100,000 till 150,000	2014	Rotterdam Buurtmonitor	-
	Value from 150,000 till 200,000	2014	Rotterdam Buurtmonitor	-
	Value from 200,000 till 250,000	2014	Rotterdam Buurtmonitor	-
	Value from 250,000 till 300,000	2014	Rotterdam Buurtmonitor	-
	Value from 300,000 till 350,000	2014	Rotterdam Buurtmonitor	-
	Value from 350,000 till 400,000	2014	Rotterdam Buurtmonitor	-
	Value from 400,000 till 450,000	2014	Rotterdam Buurtmonitor	-
	Value from 450,000 till 500,000	2014	Rotterdam Buurtmonitor	-
	Value from 500,000 and more	2014	Rotterdam Buurtmonitor	-
	Unknown value houses	2014	Rotterdam Buurtmonitor	-
	Rental housing	2014	Rotterdam Buurtmonitor	-
	Purchased housing	2014	Rotterdam Buurtmonitor	-

Concept	Variable	Year	Source	Population Group
	Unknown rent/buy	2014	Rotterdam Buurtmonitor	-
	Surface 1 m² till 44 m²	2014	Rotterdam Buurtmonitor	-
	Surface 45 m² till 59 m²	2014	Rotterdam Buurtmonitor	-
	Surface 60 m² till 74 m²	2014	Rotterdam Buurtmonitor	-
	Surface 75 m² till 89 m²	2014	Rotterdam Buurtmonitor	-
	Surface 90 m² till 119 m²	2014	Rotterdam Buurtmonitor	-
	Surface 120 m² till 149 m²	2014	Rotterdam Buurtmonitor	-
	Surface 150 m² +	2014	Rotterdam Buurtmonitor	-
	Unknown surface	2014	Rotterdam Buurtmonitor	-
	Occupancy housing is overcrowded	2014	Rotterdam Buurtmonitor	-
	Vacancy housing	2014	Rotterdam Buurtmonitor	-
	Occupancy housing is appropriate	2014	Rotterdam Buurtmonitor	-
	Occupancy housing is underused	2014	Rotterdam Buurtmonitor	-
	Sterk overbezet	2014	Rotterdam Buurtmonitor	-
	1 room houses	2014	Rotterdam Buurtmonitor	-
	2 room houses	2014	Rotterdam Buurtmonitor	-
	3 room houses	2014	Rotterdam Buurtmonitor	-
	4 room houses	2014	Rotterdam Buurtmonitor	-
	5 room houses	2014	Rotterdam Buurtmonitor	-
	6 room houses	2014	Rotterdam Buurtmonitor	-
	7 room houses	2014	Rotterdam Buurtmonitor	-
	8 and more room houses	2014	Rotterdam Buurtmonitor	-
	Houses with unknown amount of rooms	2014	Rotterdam Buurtmonitor	-
	Enough greenery nearby	2016	Rotterdam Gezondheidsmonitor	Age 19 and older
Mental health	Anxiety disorder	2016	Rotterdam Gezondheidsmonitor	Age 19 and older
	Depression	2016	Rotterdam Gezondheidsmonitor	Age 19 and older
	Burn out	2016	Rotterdam Gezondheidsmonitor	Age 19 and older
	Minimal 1 psychological disorder	2016	Rotterdam Gezondheidsmonitor	Age 19 and older
	Not happy	2016	Rotterdam Gezondheidsmonitor	Age 19 and older

Table B.2: Data dictionary after data processing

Concept	Variable	Variable Name	Data Type	Measurement Type
Geometry	Neighbourhoods Rotterdam	geometry	Polygon	-
Population Characteristics	Households	Households	Integer	Ratio
	Population	Population	Integer	Ratio
	Birth (percentage of population)	Birth	Float	Ratio
	Death (percentage of population)	Death	Float	Ratio
	Removals leaving (percentage of population)	Removals leaving	Float	Ratio
	Removals arriving (percentage of population)	Removals arriving	Float	Ratio
Economic environment	No education level (percentage of population)	No education	Float	Ratio
	Secondary education level (percentage of population)	Secondary education	Float	Ratio
	Completed bachelor or master (percentage of population)	High education	Float	Ratio

Table B.2 – continued from previous page

Concept	Variable	Variable Name	Data Type	Measurement Type
	Unemployed (percentage of population)	Unemployed	Float	Ratio
	Income	Income	Float	Ratio
	Payments welfare (percentage of population)	Payments welfare	Float	Ratio
	Clients debt assistance (percentage of population)	Debt assistance	Float	Ratio
Social environment	Social cohesion not diverging from average in region	Social cohesion mid	Integer	Ordinal
	Social cohesion lower than average in region	Social cohesion low	Integer	Ordinal
	Social cohesion higher than average in region	Social cohesion high	Integer	Ordinal
	Total crimes (percentage of population)	Total crimes	Float	Ratio
	Moderate to very lonely	Moderate to very lonely	Float	Ratio
	Seriously lonely	Seriously lonely	Float	Ratio
	Emotional lonely	Emotional lonely	Float	Ratio
	Social lonely	Social lonely	Float	Ratio
Life style	Smoking (percentage of population)	Smoking	Float	Ratio
	Moves sufficiently (own judgment) (percentage of population)	Moving own judgment	Float	Ratio
	Complies with exercise standard (NNGB) (percentage of population)	Moving standards	Float	Ratio
	Excessive drinker (percentage of population)	Excessive drinker	Float	Ratio
	Heavy drinker (percentage of population)	Heavy drinker	Float	Ratio
	Enough control over own life (percentage of population)	Enough control	Float	Ratio
	Unable to handle financial matters (their selves) (percentage of population)	Unable handle financial	Float	Ratio
	Thinks green is important (percentage of population)	Green is important	Float	Ratio
Physical environment	Inhabited addresses (percentage of population)	Inhabited addresses	Float	Ratio
	Shops	Shops	Integer	Ratio
	Total housing	Total housing	Integer	Ratio
	Age group input variables with highest percentage	Age houses	Integer	Ordinal
	Value group input variables with highest percentage	Value houses	Integer	Ordinal
	Rental housing	Rental housing	Integer	binary
	Surface group input variables with highest percentage	Surface houses	Integer	Ordinal
	Occupancy housing is overcrowded	Overcrowded	Integer	Ratio
	Room group input variable with highest percentage	Room houses	Integer	Ordinal
	Enough greenery nearby (percentage of population)	Enough green	Float	Ratio
Mental health	Anxiety disorder	Anxiety disorder	Integer	Ratio
	Depression	Depression	Integer	Ratio
	Burn out	Burn out	Integer	Ratio
	Minimal 1 psychological disorder	Min 1 disorder	Integer	Ratio
	Not happy	Not happy	Integer	Ratio

C
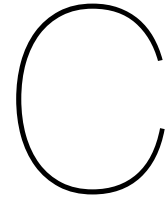
Correlations

This appendix visualizes the correlation between variables. The variables are reduced based on the correlations in using the separate concepts (C.2). The correlations between all significant variables are used to gain insight in the interconnectedness of the system.

C.1. Correlations separate concepts

This section of the correlation appendix describes the correlations for the separate concepts. First the correlation between the economic environment is visualized (Table C.1), after this correlations within the Lifestyle concept (Table C.2), Population characteristics concept (Table C.3), Physical environment concept (Table C.4) and the Social environment concept (Table C.5) are visualized. Based on these tables and logical reasoning the variables are reduced as described in Section 5.3.1.
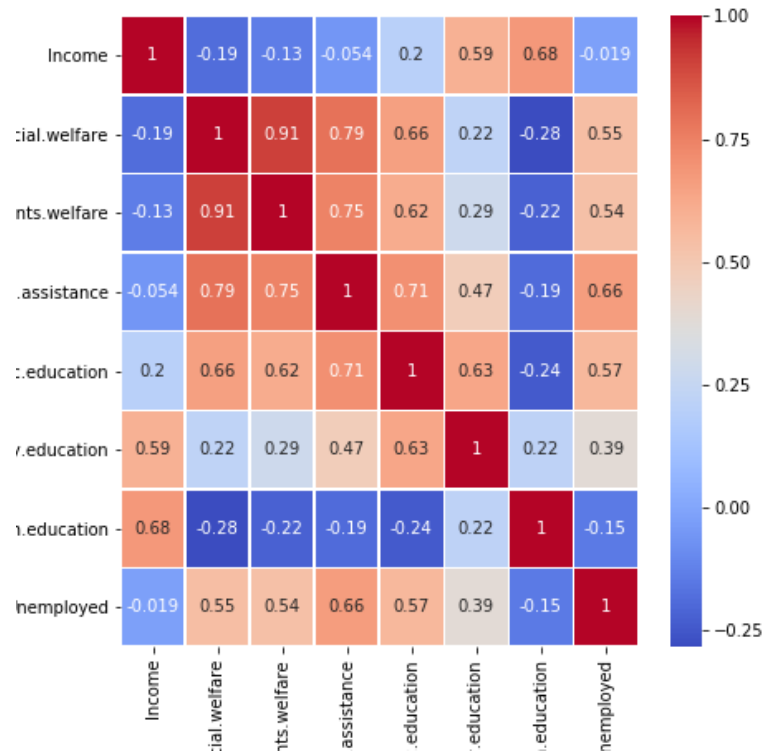
Figure C.1: Correlations of economic environment
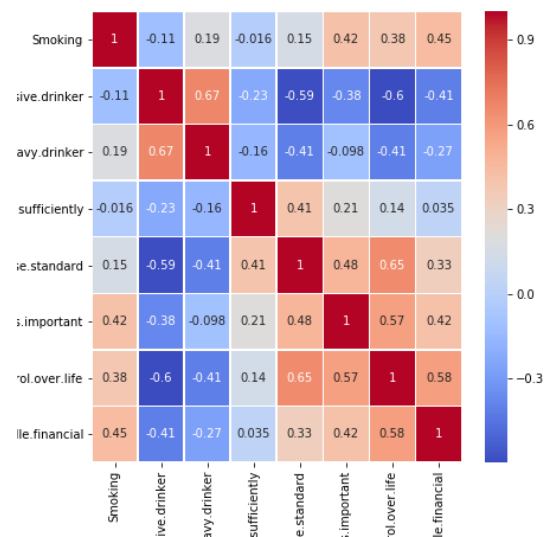
Figure C.2: Correlations of lifestyle data
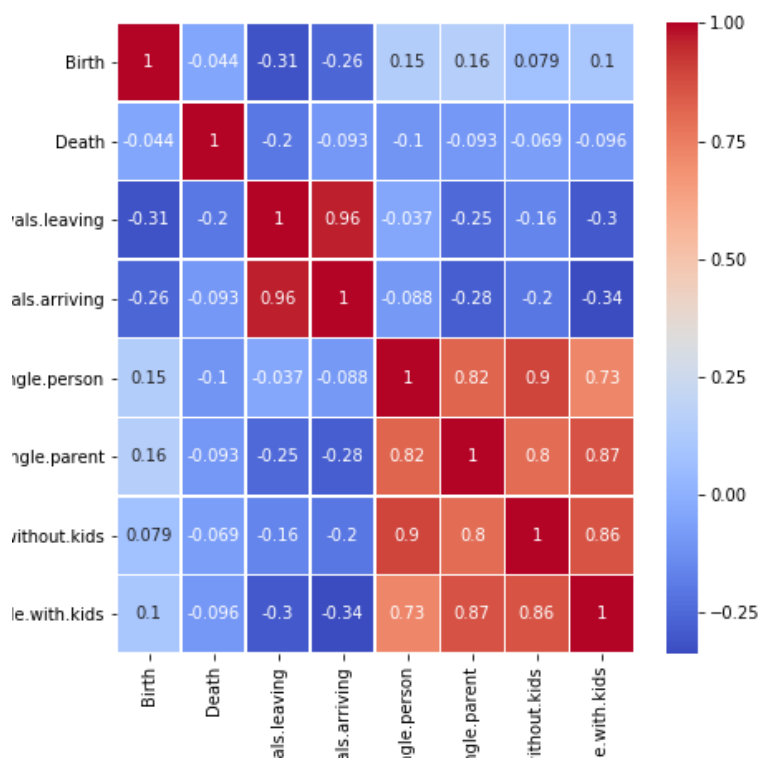
Figure C.3: Correlations of population characteristic data
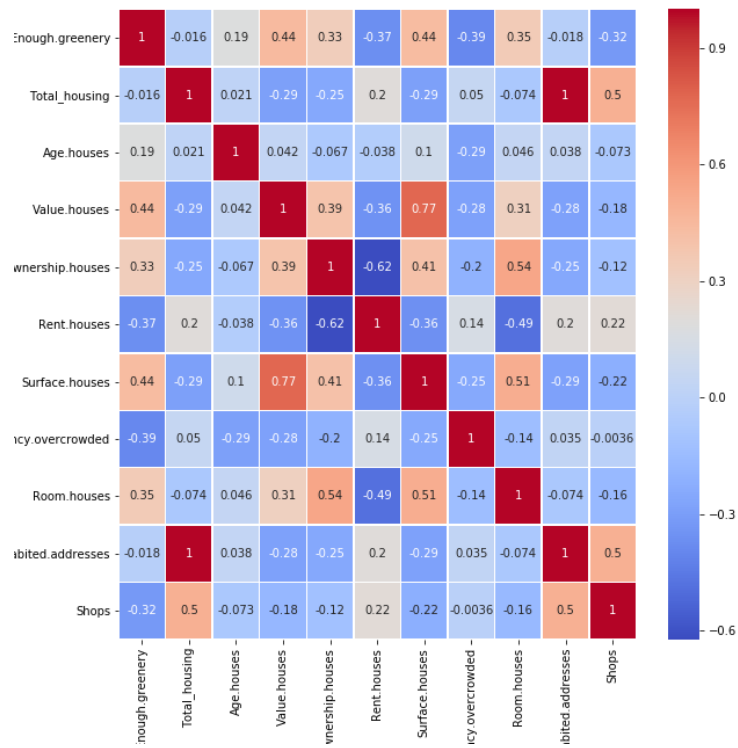
Figure C.4: Correlations of physical environment data
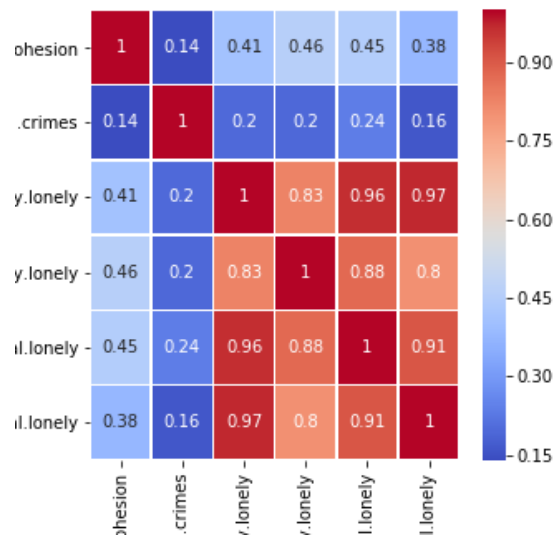
Figure C.5: Correlations of social environment data

C.2. Correlation all significant data

The figure below represents the correlations of all significant variables. High correlations indicate that there is a relation between the variables. This figure adds to the argumentation of the interconnectedness of Section 5.3.4.
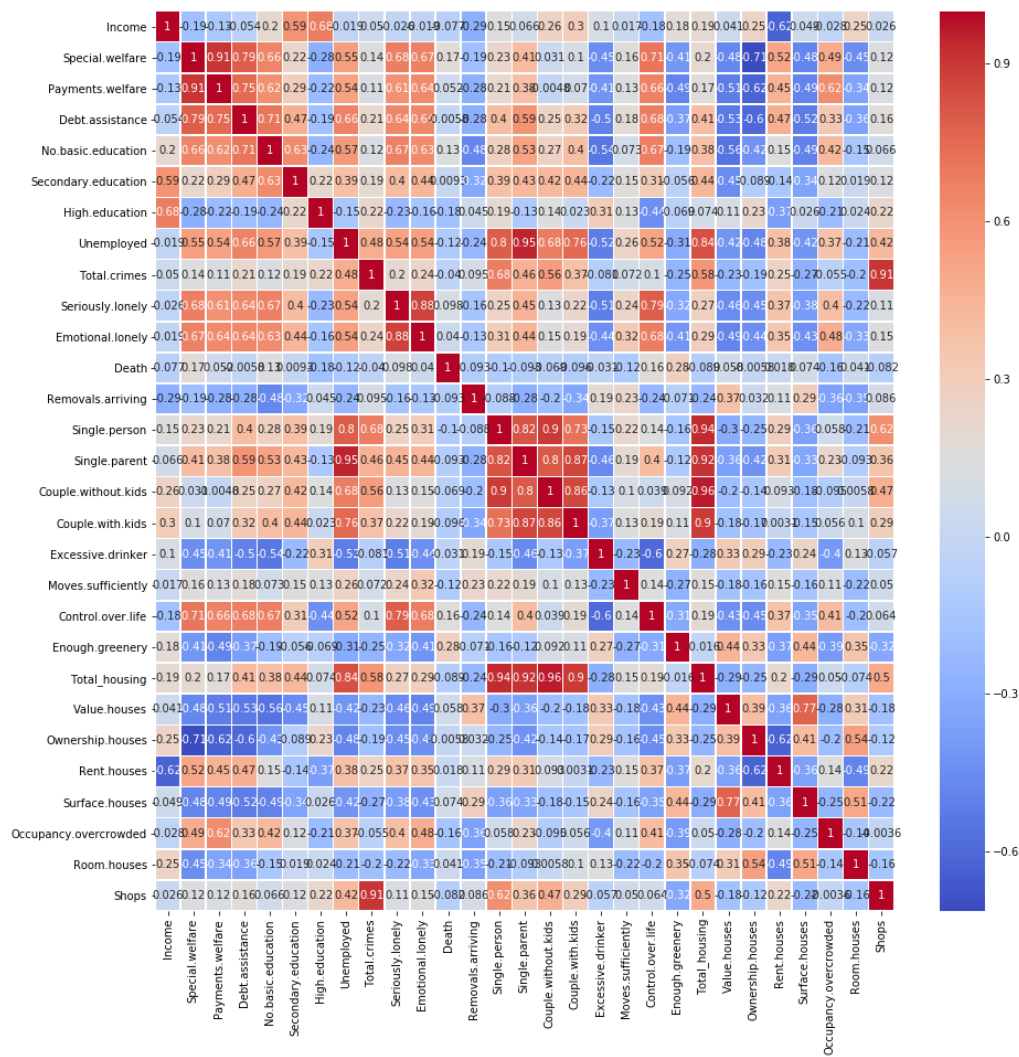
Figure C.6: Correlations of all significant data

D
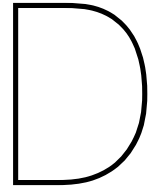
Modelling process

This Appendix gives an overview of the modeling process and ads thereby to the implementation of the modeling methods (Section 5.3). The first table describes the modelling steps based on how they are programmed in Python and R, and the description of these steps (Table D.1). The second table gives insight into the packages used in Python and R in the implementation (Table D.2), it describes these based on the action, programming language and the belonging packages. The final table gives an overview of the removed variables per variable reduction step for all the mental health outcomes (Table D.3). The first variable reduction step is based on the correlations, between the variables. For the second variable reduction step block-wise reduction is used.

Table D.1: Modelling process Python and R

Python	R	Description
Data processing		Cleaning, merging
First exploration		Visualizations, K-means, Random Forest, PCA
	Step 0	Negative Binomial modelling concepts separately, physical environment too many variables
Data processing		Reducing dimension by taking the highest represented group in neighbourhood
	Step 0	Negative Binomial modelling concepts separately, physical environment gave results
	Step 1	Look at correlations within the urban concepts, remove highly correlated (>9) with similar description
Clusters & visualization		Cluster urban concepts using k-Means and visualize results geographically
	Step 2	Negative Binomial modeling concepts separately without the highly correlated variables
	Step 3	Based on the results from step 2, remove the insignificant variables per mental health outcome
	Step 4	Negative Binomial modelling concepts separately without the insignificant variables
	Step 5	Look at the correlations of the significant for mental health outcomes separately and for the total significant
	Step 6	Select eight variables (based on P value) and Negative Binomial modelling holistic for each mental health outcome
Clusters & visualization		Cluster the predictive values from step 6 using k-Means and visualize results geographically
	Step 7a	Reduce dimension to one variable per urban concept based on the significant results of step 4
	Step 7b	Negative binomial regression of the output of step 7a
Visualizations		Visualize the output of step 7b using heat-maps
	Residuals	Validate step 6 and step 7 based on Pearson residuals plot
	Train / test	Validate step 4, 6 and 7 based on predictions of the train/test validation method

Table D.2: Packages

Action	Language	Packages
Data cleaning	Python	Pandas, numpy
Geographical data	Python	Geopandas, fiona, shapely
Data exploration and visualization	Python	Matplotlib, seaborn, missingo, sklearn
Modelling	R	AER, MASS
Visualisations	R	ggplot2
Data processing	R	dplyr, stringr, tidyverse
Train/test and residual plot	R	caret
PCA visualisation	R	factoextra

Table D.3: Removed variables per step

Step	Anxiety disorder	Burn out	Depression	Min 1 disorder	Not happy
First reduction based on correlation			Removals leaving Inhabited adresses Moderate to very lonely Social lonely		
Second reduction based on significance	Smoking	Smoking	Smoking	Smoking	Smoking
	Heavy.drinker	-	Heavy.drinker	Heavy.drinker	-
	-	-	Moves.sufficiently	Moves.sufficiently	Moves.sufficiently
	Exercise.standard	Exercise.standard	-	Exercise.standard	-
	Green.is.important	Green.is.important	Green.is.important	Green.is.important	Green.is.important
	-	Control.over.life	-	-	
	Handle.financial	Handle.financial	Handle.financial	Handle.financial	Handle.financial
	Birth	Birth	Birth	Birth	Birth
	-	Single.parent	-	-	-
	Age.houses	Age.houses	Age.houses	Age.houses	Age.houses
	-	Ownership.houses	Ownership.houses	Ownership.houses	Ownership.houses
	-	-	-	-	Rent.houses
	Surface.houses	Surface.houses			Surface.houses
	Social cohesion	Social cohesion	Social cohesion	Social cohesion	Social cohesion
	Emotional.lonely	Emotional.lonely	Emotional.lonely	Emotional.lonely	-

E

Data exploration

The first results of the modelling process are the results of the data exploration. The data used for the concepts population characteristics, life style, social environment, physical environment, economic environment and the health outcomes are clustered and geographically visualized. The table below gives an overview for the assumptions made for each of the variables (Table E.1). The first two steps of the cluster analysis are conducted according to these assumptions.

Table E.1: Assumptions for cluster analysis

Environment	Variable	Assumption	Description	Manipulation
Economic	Income	Higher income is better than lower income	Higher number indicates lower income	Yes
Economic	Special welfare	Higher percentages of special welfare is worse than lower	Higher number indicates higher special welfare	No
Economic	Payments welfare	Higher percentages of payments welfare is worse than lower	Higher number indicates higher payments welfare	No
Economic	Debt assistance	Higher percentages of payments debt assistance is worse than lower	Higher number indicates higher debt assistance	No
Economic	No basic education	Higher percentages of no basic education is worse than lower	Higher number indicates higher no basic education	No
Economic	Secondary education	Higher percentages of Secondary education is better than lower	Higher number indicates lower secondary education	Yes
Economic	High education	Higher percentages of high education is better than lower	Higher number indicates lower high education	Yes
Economic	Unemployed	Higher percentage of unemployed is worse than lower	Higher number indicates higher unemployment	No

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Table E.1 – continued from previous page

Environment	Variable	Assumption	Description	Manipulation
Lifestyle	Smoking	Higher percentage of smoking is worse than lower	Higher number indicates higher smoker	No
Lifestyle	Moving own judgment	Higher percentage of moving own judgment is better than lower	Higher number is lower moving own judgment	Yes
Lifestyle	Moving standards	Higher percentage of moving standards is better than lower	Higher number is lower moving standards	Yes
Lifestyle	Excessive drinker	Higher percentage of excessive drinker is worse than lower	Higher number is higher excessive drinker	No
Lifestyle	Heavy drinker	Higher percentage of heavy drinker is worse than lower	Higher number is higher heavy drinker	No
Lifestyle	Enough control	Higher percentage of enough control is better than lower	Higher number is lower enough control	Yes
Lifestyle	Unable handle financial	Higher percentage of unable to handle financial is worse than lower	Higher number is higher unable handle financial	No
Lifestyle	Green is important	Higher percentage of green is important is better than lower	Higher number is lower green is important	Yes
Physical	Shops	Higher percentage of shops is better than lower	Higher number is lower shops	Yes
Physical	Total housing	Higher total housing is worse than lower	Higher number is higher total housing	No
Physical	Age group houses	Higher age group is worse than lower	Higher number is lower age houses	Yes
Physical	Value group houses	Higher value group houses is better than lower	Higher number is lower value	Yes
Physical	Rental housing	Rental houses is more worse than purchased housing	Higher number is higher rental	No
Physical	Surface group houses	Higher surface houses is better than lower	Higher number is lower surface	Yes
Physical	Overcrowded	Higher overcrowding is worse than lower	Higher number is higher overcrowding	No
Physical	Rooms	Higher rooms is better than lower	Higher number is lower rooms houses	Yes
Physical	Enough green	Higher green is better than lower	Higher number is lower green is important	Yes
Social	Social cohesion	Higher social cohesion is better than lower	Higher number is lower social cohesion	Yes
Social	Total crimes	Higher crimes is worse than lower	Higher number is higher crimes	No
Social	Emotional lonely	Higher emotional lonely is worse than lower	Higher number is higher emotional lonely	No
Social	Seriously lonely	Higher seriously lonely is worse than lower	Higher number is higher seriously lonely	No
Population characteristics	Birth	Higher birth is worse than lower	Higher number is higher births	No
Population characteristics	Death	Higher death is worse than lower	Higher number is higher deaths	No

Continued on next page

Table E.1 – continued from previous page

Environment	Variable	Assumption	Description	Manipulation
Population characteristics	Removals arriving	Higher removals arriving is worse than lower	Higher number is higher removals arriving	No
Population characteristics	Single person	Higher single person is worse than lower	Higher number is higher single person	No
Population characteristics	Single parent	Higher single parent is worse than lower	Higher number is higher single parent	No
Population characteristics	Couple without kids	Higher couple without kids is better than lower	Higher number is lower couple without kids	Yes
Population characteristics	Couple with kids	Higher couple with kids is worse than lower	Higher number is higher couple with kids	No

F

Results Negative Binomial

This appendix discusses the modeling results. Four of the total amount of models are used as output. The first one are the models of all significant variables in which the concepts are modelled separately (F.1). The second output are the where the eight most important variables are modelled holistic (F.2). The third output are the models of a selection of the variables (F.3). The last model is the model in which the first PCA of each concept is included (F.4).

F.1. Results negative binomial step 4

The table below summarizes the output of the models that model all significant variable. This table show the Estimate, the standard error, the Z-value, the P-value, the coefficient, the belonging concept and mental health output and the value for theta. Based on this table the Figure 6.2 is made and the table adds to the results disused in this section (Section 6.1.2).

Table F.1: A sample long table.

Estimate	Std..Error	z.value	Pr...z..	coeficients	data	theta
1.7401	0.1347	12.9192	0.00000	(Intercept)	Anxiety disorder EE	2.449
0.0235	0.0046	5.0638	0.00000	Income	Anxiety disorder EE	2.449
11.3520	2.4402	4.6521	0.00000	Special.welfare	Anxiety disorder EE	2.449
-18.4326	2.1958	-8.3946	0.00000	Payments.welfare	Anxiety disorder EE	2.449
39.6776	8.7425	4.5385	0.00001	Debt.assistance	Anxiety disorder EE	2.449
0.8032	0.3611	2.2243	0.02613	No.basic.education	Anxiety disorder EE	2.449
3.0972	0.3589	8.6291	0.00000	Secondary.education	Anxiety disorder EE	2.449
2.0607	0.2665	7.7335	0.00000	High.education	Anxiety disorder EE	2.449
0.0014	0.0000	28.5952	0.00000	Unemployed	Anxiety disorder EE	2.449
5.1865	0.3595	14.4266	0.00000	(Intercept)	Anxiety disorder LS	0.976
-7.6110	1.9399	-3.9233	0.00009	Excessive.drinker	Anxiety disorder LS	0.976
2.3576	0.9111	2.5877	0.00966	Moves.sufficiently	Anxiety disorder LS	0.976
3.7845	0.8221	4.6032	0.00000	Control.over.life	Anxiety disorder LS	0.976
4.6870	0.0737	63.5610	0.00000	(Intercept)	Anxiety disorder PC	2.003
-14.8009	2.3145	-6.3948	0.00000	Death	Anxiety disorder PC	2.003

Continued on next page

Table F.1 – continued from previous page

Estimate	Std..Error	z.value	Pr...z..	coeficients	data	theta
-4.5638	0.4936	-9.2454	0.00000	Removals.arriving	Anxiety disorder PC	2.003
0.0006	0.0001	10.3051	0.00000	Single.person	Anxiety disorder PC	2.003
0.0006	0.0002	3.0639	0.00218	Single.parent	Anxiety disorder PC	2.003
-0.0005	0.0001	-4.1658	0.00003	Couple.without.kids	Anxiety disorder PC	2.003
0.0006	0.0001	4.3257	0.00002	Couple.with.kids	Anxiety disorder PC	2.003
5.9973	0.2586	23.1952	0.00000	(Intercept)	Anxiety disorder PE	2.009
-0.9158	0.2357	-3.8857	0.00010	Enough.greenery	Anxiety disorder PE	2.009
0.0004	0.0000	31.7012	0.00000	Total_housing	Anxiety disorder PE	2.009
-0.1046	0.0166	-6.2972	0.00000	Value.houses	Anxiety disorder PE	2.009
-0.0238	0.0114	-2.0916	0.03647	Ownership.houses	Anxiety disorder PE	2.009
-0.6512	0.0979	-6.6504	0.00000	Rent.houses	Anxiety disorder PE	2.009
3.7247	1.2777	2.9151	0.00356	Occupancy.overcrowded	Anxiety disorder PE	2.009
-0.1120	0.0395	-2.8349	0.00458	Room.houses	Anxiety disorder PE	2.009
-0.0014	0.0003	-5.6775	0.00000	Shops	Anxiety disorder PE	2.009
4.2016	0.1485	28.2869	0.00000	(Intercept)	Anxiety disorder SE	1.066
0.0010	0.0001	16.2100	0.00000	Total.crimes	Anxiety disorder SE	1.066
2.6219	0.4065	6.4505	0.00000	Emotional.lonely	Anxiety disorder SE	1.066
2.3186	0.1158	20.0166	0.00000	(Intercept)	Burn out EE	3.078
0.0264	0.0041	6.4454	0.00000	Income	Burn out EE	3.078
6.2642	2.1572	2.9038	0.00369	Special.welfare	Burn out EE	3.078
-14.7522	1.9350	-7.6238	0.00000	Payments.welfare	Burn out EE	3.078
57.5520	7.7452	7.4307	0.00000	Debt.assistance	Burn out EE	3.078
1.5538	0.3184	4.8808	0.00000	No.basic.education	Burn out EE	3.078
2.1530	0.3174	6.7831	0.00000	Secondary.education	Burn out EE	3.078
3.0091	0.2348	12.8147	0.00000	High.education	Burn out EE	3.078
0.0014	0.0000	32.4279	0.00000	Unemployed	Burn out EE	3.078
6.7742	0.3106	21.8086	0.00000	(Intercept)	Burn out LS	1.026
-16.8622	2.0609	-8.1820	0.00000	Excessive.drinker	Burn out LS	1.026
3.4598	1.4059	2.4608	0.01386	Heavy.drinker	Burn out LS	1.026
2.6316	0.8883	2.9626	0.00305	Moves.sufficiently	Burn out LS	1.026
5.4953	0.0676	81.2832	0.00000	(Intercept)	Burn out PC	2.330
-10.4217	2.0724	-5.0288	0.00000	Death	Burn out PC	2.330
-4.9043	0.4349	-11.2774	0.00000	Removals.arriving	Burn out PC	2.330
0.0008	0.0000	21.6549	0.00000	Single.person	Burn out PC	2.330
-0.0012	0.0001	-10.8616	0.00000	Couple.without.kids	Burn out PC	2.330
0.0010	0.0001	11.9577	0.00000	Couple.with.kids	Burn out PC	2.330
6.4522	0.2447	26.3726	0.00000	(Intercept)	Burn out PE	2.106
-1.1930	0.2285	-5.2222	0.00000	Enough.greenery	Burn out PE	2.106
0.0004	0.0000	33.8335	0.00000	Total_housing	Burn out PE	2.106
-0.0597	0.0160	-3.7260	0.00019	Value.houses	Burn out PE	2.106
-0.3830	0.0844	-4.5378	0.00001	Rent.houses	Burn out PE	2.106
5.3050	1.2361	4.2916	0.00002	Occupancy.overcrowded	Burn out PE	2.106
-0.0997	0.0372	-2.6791	0.00738	Room.houses	Burn out PE	2.106
-0.0013	0.0002	-5.4802	0.00000	Shops	Burn out PE	2.106
5.3496	0.1015	52.7166	0.00000	(Intercept)	Burn out SE	1.181
0.0010	0.0001	18.2315	0.00000	Total.crimes	Burn out SE	1.181
4.6669	0.6766	6.8972	0.00000	Seriously.lonely	Burn out SE	1.181
1.9054	0.1182	16.1196	0.00000	(Intercept)	Depression EE	3.250
0.0383	0.0040	9.5673	0.00000	Income	Depression EE	3.250
8.4202	2.1179	3.9757	0.00007	Special.welfare	Depression EE	3.250
-13.4681	1.8966	-7.1010	0.00000	Payments.welfare	Depression EE	3.250
52.1746	7.5668	6.8952	0.00000	Debt.assistance	Depression EE	3.250
1.0393	0.3114	3.3375	0.00085	No.basic.education	Depression EE	3.250
2.3510	0.3113	7.5514	0.00000	Secondary.education	Depression EE	3.250
1.4443	0.2298	6.2858	0.00000	High.education	Depression EE	3.250
0.0013	0.0000	30.7935	0.00000	Unemployed	Depression EE	3.250
5.1555	0.3428	15.0400	0.00000	(Intercept)	Depression LS	1.078
-4.6302	1.9295	-2.3997	0.01641	Excessive.drinker	Depression LS	1.078
2.0825	0.6623	3.1445	0.00166	Exercise.standard	Depression LS	1.078
3.7061	0.8805	4.2090	0.00003	Control.over.life	Depression LS	1.078
4.9335	0.0684	72.1385	0.00000	(Intercept)	Depression PC	2.265
-9.2735	2.1184	-4.3776	0.00001	Death	Depression PC	2.265
-3.1720	0.4411	-7.1919	0.00000	Removals.arriving	Depression PC	2.265
0.0006	0.0001	10.7559	0.00000	Single.person	Depression PC	2.265
0.0009	0.0002	5.2322	0.00000	Single.parent	Depression PC	2.265
-0.0009	0.0001	-7.4276	0.00000	Couple.without.kids	Depression PC	2.265
0.0008	0.0001	6.3540	0.00000	Couple.with.kids	Depression PC	2.265
5.9319	0.2419	24.5207	0.00000	(Intercept)	Depression PE	2.170
-1.1747	0.2261	-5.1958	0.00000	Enough.greenery	Depression PE	2.170
0.0004	0.0000	32.5733	0.00000	Total_housing	Depression PE	2.170
-0.1182	0.0210	-5.6152	0.00000	Value.houses	Depression PE	2.170
-0.3661	0.0841	-4.3522	0.00001	Rent.houses	Depression PE	2.170
0.1281	0.0375	3.4104	0.00065	Surface.houses	Depression PE	2.170

Table F.1 – continued from previous page

Estimate	Std..Error	z.value	Pr...z..	coeficients	data	theta
4.9869	1.2207	4.0854	0.00004	Occupancy.overcrowded	Depression PE	2.170
-0.1488	0.0411	-3.6207	0.00029	Room.houses	Depression PE	2.170
-0.0016	0.0002	-6.5747	0.00000	Shops	Depression PE	2.170
4.6251	0.1000	46.2514	0.00000	(Intercept)	Depression SE	1.219
0.0009	0.0001	16.3339	0.00000	Total.crimes	Depression SE	1.219
6.6800	0.6665	10.0219	0.00000	Seriously.lonely	Depression SE	1.219
2.4359	0.1125	21.6516	0.00000	(Intercept)	Min1 disorder EE	3.183
0.0315	0.0040	7.8507	0.00000	Income	Min1 disorder EE	3.183
8.4233	2.1161	3.9807	0.00007	Special.welfare	Min1 disorder EE	3.183
-14.8954	1.8977	-7.8491	0.00000	Payments.welfare	Min1 disorder EE	3.183
42.7803	7.6110	5.6208	0.00000	Debt.assistance	Min1 disorder EE	3.183
1.2242	0.3114	3.9306	0.00008	No.basic.education	Min1 disorder EE	3.183
2.3800	0.3116	7.6377	0.00000	Secondary.education	Min1 disorder EE	3.183
1.9975	0.2294	8.7086	0.00000	High.education	Min disorder EE	3.183
0.0013	0.0000	30.9405	0.00000	Unemployed	Min1 disorder EE	3.183
6.6535	0.1982	33.5652	0.00000	(Intercept)	Min1 disorder LS	1.083
-7.2898	1.8180	-4.0098	0.00006	Excessive.drinker	Min1 disorder LS	1.083
3.6489	0.7801	4.6777	0.00000	Control.over.life	Min1 disorder LS	1.083
5.4360	0.0665	81.6906	0.00000	(Intercept)	Min1 disorder PC	2.399
-9.6788	2.0463	-4.7298	0.00000	Death	Min1 disorder PC	2.399
-4.4769	0.4347	-10.2999	0.00000	Removals.arriving	Min1 disorder PC	2.399
0.0006	0.0001	12.4428	0.00000	Single.person	Min1 disorder PC	2.399
0.0004	0.0002	2.1538	0.03126	Single.parent	Min1 disorder PC	2.399
-0.0007	0.0001	-6.3672	0.00000	Couple.without.kids	Min1 disorder PC	2.399
0.0007	0.0001	6.2709	0.00000	Couple.with.kids	Min1 disorder PC	2.399
6.6700	0.2344	28.4595	0.00000	(Intercept)	Min1 disorder PE	2.305
-1.0333	0.2190	-4.7180	0.00000	Enough.greenery	Min1 disorder PE	2.305
0.0004	0.0000	33.7243	0.00000	Total_housing	Min1 disorder PE	2.305
-0.1086	0.0204	-5.3318	0.00000	Value.houses	Min1 disorder PE	2.305
-0.5165	0.0815	-6.3384	0.00000	Rent.houses	Min1 disorder PE	2.305
0.0886	0.0364	2.4350	0.01489	Surface.houses	Min1 disorder PE	2.305
3.4612	1.1829	2.9260	0.00343	Occupancy.overcrowded	Min1 disorder PE	2.305
-0.2031	0.0398	-5.1099	0.00000	Room.houses	Min1 disorder PE	2.305
-0.0012	0.0002	-5.2342	0.00000	Shops	Min1 disorder PE	2.305
5.2437	0.0992	52.8372	0.00000	(Intercept)	Min1 disorder SE	1.235
0.0009	0.0001	16.9249	0.00000	Total.crimes	Min1 disorder SE	1.235
4.9317	0.6617	7.4532	0.00000	Seriously.lonely	Min1 disorder SE	1.235
2.1579	0.1075	20.0703	0.00000	(Intercept)	Not happy EE	3.898
0.0202	0.0037	5.4966	0.00000	Income	Not happy EE	3.898
12.3056	1.9297	6.3769	0.00000	Special.welfare	Not happy EE	3.898
-20.0572	1.7360	-11.5534	0.00000	Payments.welfare	Not happy EE	3.898
56.1586	6.8938	8.1463	0.00000	Debt.assistance	Not happy EE	3.898
2.7284	0.2855	9.5573	0.00000	No.basic.education	Not happy EE	3.898
2.7070	0.2841	9.5277	0.00000	Secondary.education	Not happy EE	3.898
2.8357	0.2118	13.3869	0.00000	High.education	Not happy EE	3.898
0.0012	0.0000	33.1601	0.00000	Unemployed	Not happy EE	3.898
5.9692	0.3378	17.6727	0.00000	(Intercept)	Not happy LS	1.142
-11.4007	2.2606	-5.0432	0.00000	Excessive.drinker	Not happy LS	1.142
2.7225	1.3340	2.0408	0.04127	Heavy.drinker	Not happy LS	1.142
2.0821	0.6442	3.2320	0.00123	Exercise.standard	Not happy LS	1.142
3.8849	0.8555	4.5411	0.00001	Control.over.life	Not happy LS	1.142
5.7077	0.0692	82.4347	0.00000	(Intercept)	Not happy PC	2.206
-5.1515	2.1149	-2.4358	0.01486	Death	Not happy PC	2.206
-4.9259	0.4517	-10.9043	0.00000	Removals.arriving	Not happy PC	2.206
0.0007	0.0001	12.3330	0.00000	Single.person	Not happy PC	2.206
0.0008	0.0002	4.6346	0.00000	Single.parent	Not happy PC	2.206
-0.0010	0.0001	-7.8284	0.00000	Couple.without.kids	Not happy PC	2.206
0.0007	0.0001	5.5829	0.00000	Couple.with.kids	Not happy PC	2.206
5.9640	0.1944	30.6749	0.00000	(Intercept)	Not happy PE	2.154
-0.7847	0.2233	-3.5148	0.00044	Enough.greenery	Not happy PE	2.154
0.0003	0.0000	31.1115	0.00000	Total_housing	Not happy PE	2.154
-0.0615	0.0155	-3.9689	0.00007	Value.houses	Not happy PE	2.154
8.7669	1.2204	7.1835	0.00000	Occupancy.overcrowded	Not happy PE	2.154
-0.0795	0.0334	-2.3768	0.01747	Room.houses	Not happy PE	2.154
-0.0010	0.0002	-4.2386	0.00002	Shops	Not happy PE	2.154
4.8570	0.1453	33.4230	0.00000	(Intercept)	Not happy SE	1.261
0.0009	0.0001	15.9863	0.00000	Total.crimes	Not happy SE	1.261
4.3796	1.2913	3.3915	0.00070	Seriously.lonely	Not happy SE	1.261
2.1409	0.7363	2.9078	0.00364	Emotional.lonely	Not happy SE	1.261

F.2. Eight variables modelled holistic

The table below (Table F.2) shows the results of the models which models the eight most important variables holistic for each mental health outcome. For each coefficient it shows the estimate, the standard error, the z value, the P-value, the belonging mental health outcome and the theta. Table 6.1 of the main report summarizes the coefficients in this table and this table adds to the description of this section (Section 6.1.3). The next table (Table F.3) describes the predicted values of the models for each neighbourhood for each mental health outcome. This predicted values are clustered and visualized in Figure 6.5 of the main report.

Table F.2: Results negative binomial step 6

Estimate	Std..Error	z.value	Pr...z..	coeficients	data	theta
2.0691	0.1359	15.2205	2.59E-52	(Intercept)	Anxiety disorder	2.7021
6.5056	1.3527	4.8093	1.51E-06	Payments.welfare	Anxiety disorder	2.7021
4.0044	0.2525	15.8609	1.18E-56	Secondary.education	Anxiety disorder	2.7021
2.4130	0.1851	13.0352	7.72E-39	High.education	Anxiety disorder	2.7021
0.0007	0.0001	6.7635	1.35E-11	Unemployed	Anxiety disorder	2.7021
-1.5136	0.5335	-2.8370	4.55E-03	Removals.arriving	Anxiety disorder	2.7021
0.0000	0.0001	-0.5375	5.91E-01	Single.person	Anxiety disorder	2.7021
0.0002	0.0000	5.9633	2.47E-09	Total housing	Anxiety disorder	2.7021
-0.0003	0.0001	-6.6837	2.33E-11	Total.crimes	Anxiety disorder	2.7021
4.7067	0.0793	59.3187	0.00E+00	(Intercept)	Burn out	2.5151
1.9216	0.1982	9.6948	3.17E-22	High.education	Burn out	2.5151
0.0007	0.0001	6.2219	4.91E-10	Unemployed	Burn out	2.5151
-3.7621	0.4542	-8.2823	1.21E-16	Removals.arriving	Burn out	2.5151
0.0005	0.0001	5.9213	3.19E-09	Single.person	Burn out	2.5151
-0.0007	0.0002	-3.4819	4.98E-04	Couple.without.kids	Burn out	2.5151
0.0007	0.0002	4.5483	5.41E-06	Couple.with.kids	Burn out	2.5151
0.0000	0.0001	0.2229	8.24E-01	Total housing	Burn out	2.5151
-0.0002	0.0001	-4.1893	2.80E-05	Total.crimes	Burn out	2.5151
1.7097	0.1144	14.9449	1.68E-50	(Intercept)	Depression	3.3138
0.0465	0.0028	16.4616	6.93E-61	Income	Depression	3.3138
2.7090	0.2581	10.4958	9.03E-26	Secondary.education	Depression	3.3138
0.0005	0.0001	5.2888	1.23E-07	Unemployed	Depression	3.3138
0.0003	0.0000	5.6587	1.52E-08	Single.person	Depression	3.3138
-0.0009	0.0002	-5.1296	2.90E-07	Couple.without.kids	Depression	3.3138
0.0003	0.0001	4.9905	6.02E-07	Total housing	Depression	3.3138
-0.0002	0.0000	-4.9818	6.30E-07	Total.crimes	Depression	3.3138
5.1366	0.5792	8.8686	7.41E-19	Seriously.lonely	Depression	3.3138
2.9716	0.1321	22.5029	3.88E-112	(Intercept)	Min1 disorder	2.8863
0.0502	0.0037	13.6383	2.37E-42	Income	Min1 disorder	2.8863
10.3354	1.2803	8.0725	6.89E-16	Payments.welfare	Min1 disorder	2.8863
0.3995	0.2379	1.6796	9.30E-02	High.education	Min1 disorder	2.8863
0.0006	0.0001	5.8503	4.91E-09	Unemployed	Min1 disorder	2.8863
-0.9270	0.4673	-1.9839	4.73E-02	Removals.arriving	Min1 disorder	2.8863
0.0002	0.0001	2.6387	8.32E-03	Single.person	Min1 disorder	2.8863
0.0002	0.0000	4.6211	3.82E-06	Total housing	Min1 disorder	2.8863
-0.0002	0.0000	-4.2551	2.09E-05	Total.crimes	Min1 disorder	2.8863
2.5181	0.1233	20.4233	1.04E-92	(Intercept)	Not happy	3.4840
-1.8630	1.2392	-1.5034	1.33E-01	Payments.welfare	Not happy	3.4840
6.2790	0.2460	25.5252	1.04E-143	No.basic.education	Not happy	3.4840
3.5363	0.1692	20.8989	5.48E-97	High.education	Not happy	3.4840
0.0005	0.0001	5.2836	1.27E-07	Unemployed	Not happy	3.4840
0.2960	0.4348	0.6807	4.96E-01	Removals.arriving	Not happy	3.4840
0.0002	0.0001	3.4052	6.61E-04	Single.person	Not happy	3.4840
0.0001	0.0000	4.5083	6.53E-06	Total housing	Not happy	3.4840
-0.0002	0.0000	-5.4459	5.15E-08	Total.crimes	Not happy	3.4840

Table F.3: Predicted values step 6

Neighbourhood	Anxiety disorder	Burn out	Depression	Min1 disorder	Not happy
AFRIKAANDERWIJK	5.8903	6.793530181	6.8490	7.0032	7.5021
AGNIESEBUURT	5.0844	6.18076256	5.3486	5.8389	6.4522
BERGPOLDER	5.9885	6.86030758	5.7607	6.3737	6.7960
BEVERWAARD	6.3021	6.789806575	6.9147	6.8609	7.0628
BLIJDORP	5.7310	6.966605825	5.6406	6.4418	6.8537
BLIJDORPSEPOLDER	0.9900	2.240303933	2.1790	2.3271	2.6627
BLOEMHOF	6.8541	7.952811292	7.5824	7.6975	8.2604
BOSPOLDER	5.7134	6.521093737	6.2059	6.4855	6.9932
CARNISSE	6.1863	7.116399978	7.1270	6.6484	7.4119

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Table F.3 – continued from previous page

Neighbourhood	Anxiety disorder	Burn out	Depression	Min1 disorder	Not happy
CHARLOISZUIDRAND	4.2203	4.759253532	5.7793	5.4400	5.7103
COOL	4.0623	5.193997435	4.6289	5.0897	5.7350
DEESCH	5.4348	6.023050256	5.5603	5.9623	6.1626
DELFSHAVEN	5.7855	6.57495075	5.7196	6.4836	6.7795
DIJKZIGT	4.7736	5.644657522	4.4611	4.7258	5.0749
DORP	5.5070	5.747080402	5.6120	5.9009	6.2860
FEIJENOORD	5.7732	6.623120873	6.6039	6.7849	7.4116
GROOTIJSSELMONDE	8.5494	9.586552626	8.9484	9.4313	9.7003
HEIJPLAAT	4.9239	5.002745696	5.1699	5.3218	5.4792
HETLAGELAND	5.9261	6.769998488	6.2741	6.4067	6.7271
HILLEGERSBERGNOORD	5.4357	6.349056641	5.8579	6.5418	6.5320
HILLEGERSBERGZUID	5.3737	6.456398011	5.4284	6.1108	6.3485
HILLESLUIS	6.2493	7.269470082	7.0128	6.8996	7.3684
HOOGVLIETNOORD	6.0749	6.763810246	6.6778	6.6591	7.0410
HOOGVLIETZUID	7.2773	7.510913487	7.0101	7.8729	8.0461
KATENDRECHT	5.2358	6.082270812	5.2994	5.9198	6.4643
KLEINPOLDER	5.5243	6.449580658	5.8692	6.2528	7.0767
KOPVANZUID	4.7525	5.442340036	5.5630	5.3326	5.4290
KOPVANZUIDENTREPOT	5.6968	6.678946677	6.1056	6.5917	6.7793
KRALINGENOOST	5.1812	6.593605114	6.9254	6.9254	6.2044
KRALINGENWEST	6.9238	8.435727168	7.0402	7.9007	8.1040
KRALINGSEBOS	2.1370	4.600715119	1.8115	3.1907	2.4201
KRALINGSEVEER	3.5924	5.043393804	4.4931	4.9938	7.0920
LANDZICHT	2.5495	4.721456843	3.3613	4.9589	2.4520
LISKWARTIER	5.6143	6.644553536	5.6346	6.2679	6.6758
LOMBARDIJEN	6.6095	7.453124299	7.4169	7.2639	7.6193
MIDDELLAND	6.2604	7.59898706	7.1173	7.1173	7.4317
MOLENLAANKWARTIER	5.1570	6.683655274	5.6748	6.6965	6.4186
NESSELANDE	5.5887	6.960147805	5.9883	6.4935	6.2548
NIEUWCROOSWIJK	5.1064	5.707881205	4.9618	5.4485	6.2289
NIEUWEWERK	4.5047	5.193752354	5.4395	5.6958	5.3875
NIEUWEWESTEN	7.5143	9.3641282	7.6938	8.5182	8.8372
NIEUWMATHENESSE	1.6992	3.948554169	2.4244	2.7470	2.5141
NIEUWMATHENESSE	1.6992	3.948554169	1.6539	2.7470	2.5141
NOORDEREILAND	5.0701	5.816623918	4.9306	5.7881	6.3767
NOORDKETHEL	1.9846	4.482581173	2.1694	2.9224	2.5415
OMMOORD	7.8381	8.449299145	7.4552	8.6269	8.9877
OOSTERFLANK	5.9712	6.837629856	6.5038	6.6503	6.9778
OUDCHARLOIS	6.6594	7.612727505	7.1713	7.3285	7.7902
OUDCROOSWIJK	5.8789	6.81430027	6.5269	6.8397	7.5623
OUDENOORDEN	7.5100	8.860616775	7.7584	8.4300	8.5247
OUDEWESTEN	6.2902	7.161042977	6.4756	7.1033	6.9959
OUDIJSSELMONDE	5.1599	5.706819062	5.2550	5.7679	5.8752
OUDMATHENESSE	5.4628	6.235098684	5.9970	5.9187	6.8535
OVERSCHIE	5.4205	5.938860744	5.5427	5.9268	6.1542
PENDRECHT	6.4731	7.322147778	6.7520	7.0750	7.3836
PERNIS	4.9976	5.381692605	5.4822	5.4189	5.8440
PRINSENLAND	5.0043	6.513689407	5.9671	6.5675	6.4740
PROVENIERSWIJK	5.1475	6.227241462	4.9819	5.8202	6.3844
RIJNPOORT	2.0333	4.383957908	2.1714	3.0424	2.5181
ROZENBURG	5.8899	6.093089593	6.1230	6.2536	6.6435
RUBROEK	5.9847	6.727909896	6.1575	6.5313	6.7406
SCHIEBROEK	6.7418	8.209345856	7.2991	7.5733	7.9038
SCHIEMOND	5.3720	6.090628782	5.0608	6.2379	6.5594
SCHIEVEEN	5.5779	4.972935968	5.4082	6.2714	4.5045
SGRAVENLAND	5.2864	6.301321152	5.8502	6.4350	6.0822
SPAANSEPOLDER	1.9108	4.039521651	2.0876	3.0818	2.4220
SPAANSEPOLDER	1.9108	4.039521651	1.6253	3.0818	2.4220
SPANGEN	6.0210	7.15608114	6.3495	6.7167	7.3618
STADSDRIEHOEK	5.4858	7.23002387	6.0342	7.0541	7.1266
STRANDENDUIN	4.6702	5.193077576	5.5810	5.6035	5.2769
STRUISENBURG	5.2164	5.637560434	6.1605	5.6224	5.2367
TARWEWIJK	6.5967	7.294990885	7.0168	7.0724	7.3138
TERBREGGE	4.7813	5.626687835	5.4974	5.9236	5.7365
TUSSENDIJKEN	5.6754	6.647081771	6.0969	6.5115	7.2583
VREEWIJK	6.7604	7.480960619	7.3597	7.6821	8.1872
WIELEWAAL	4.6933	5.000845301	5.0298	5.1786	5.8630
WITTEDORP	4.3279	4.993706718	4.6748	5.4858	6.3974
ZESTIENHOVEN	4.7218	5.865553078	4.9437	5.5046	5.4250
ZEVENKAMP	6.8349	7.617292726	7.1723	7.3679	7.4064
ZUIDERPARK	4.2174	4.653819101	4.7578	4.8120	5.8764
ZUIDPLEIN	4.0192	4.773363232	4.8549	4.5465	5.5750

F.3. Interconnectedness

The table below (F.4) shows the models for total crimes, high educated, no basic education and unemployed. It gives for each coefficient the estimate, standard error, z-value, P-value, the belonging variable and concept, and the theta. It adds to the explanation of Section 5.3.4 of the report. As visual in the table, the negative binomial is a bad fit for high education and no basic education. These results are not considered in the argumentation of this thesis.

Table F.4: Results unemployed, high education, no education and total crimes

Estimate	Std..Error	z.value	Pr...z..	coeficients	data	theta
2.4557	0.1494	16.4392	1.00E-60	(Intercept)	Unemployed_EE	1.5266
0.0339	0.0041	8.3594	6.30E-17	Income	Unemployed_EE	1.5266
5.5329	1.6824	3.2887	1.01E-03	Special.welfare	Unemployed_EE	1.5266
132.6130	10.3608	12.7995	1.65E-37	Debt.assistance	Unemployed_EE	1.5266
4.2899	0.3872	11.0786	1.59E-28	Secondary.education	Unemployed_EE	1.5266
5.3476	0.3481	15.3610	2.99E-53	(Intercept)	Unemployed_LS	1.0843
-13.4889	2.3473	-5.7466	9.11E-09	Excessive.drinker	Unemployed_LS	1.0843
3.9527	1.4173	2.7889	5.29E-03	Heavy.drinker	Unemployed_LS	1.0843
2.6524	0.6729	3.9419	8.08E-05	Exercise.standard	Unemployed_LS	1.0843
2.5091	0.9961	2.5189	1.18E-02	Green.is.important	Unemployed_LS	1.0843
2.8554	0.9491	3.0085	2.63E-03	Control.over.life	Unemployed_LS	1.0843
5.1671	0.1100	46.9525	0.00E+00	(Intercept)	Unemployed_PC	2.4211
18.0805	6.3007	2.8696	4.11E-03	Birth	Unemployed_PC	2.4211
-13.4600	2.0797	-6.4721	9.67E-11	Death	Unemployed_PC	2.4211
-4.7826	0.4545	-10.5238	6.71E-26	Removals.arriving	Unemployed_PC	2.4211
0.0006	0.0001	11.4278	3.04E-30	Single.person	Unemployed_PC	2.4211
0.0017	0.0002	9.6924	3.25E-22	Single.parent	Unemployed_PC	2.4211
-0.0009	0.0001	-7.2500	4.17E-13	Couple.without.kids	Unemployed_PC	2.4211
0.0003	0.0001	2.2880	2.21E-02	Couple.with.kids	Unemployed_PC	2.4211
6.8371	0.2261	30.2365	7.85E-201	(Intercept)	Unemployed_PE	2.6112
-1.0238	0.2063	-4.9636	6.92E-07	Enough.greenery	Unemployed_PE	2.6112
0.0004	0.0000	34.0799	1.46E-254	Total_housing	Unemployed_PE	2.6112
-0.1449	0.0146	-9.9368	2.88E-23	Value.houses	Unemployed_PE	2.6112
-0.0505	0.0099	-5.0786	3.80E-07	Ownership.houses	Unemployed_PE	2.6112
-0.3486	0.0858	-4.0642	4.82E-05	Rent.houses	Unemployed_PE	2.6112
7.4874	1.1169	6.7036	2.03E-11	Occupancy.overcrowded	Unemployed_PE	2.6112
-0.1737	0.0346	-5.0267	4.99E-07	Room.houses	Unemployed_PE	2.6112
-0.0008	0.0002	-3.5668	3.61E-04	Shops	Unemployed_PE	2.6112
4.1295	0.1569	26.3216	1.09E-152	(Intercept)	Unemployed_SE	1.0808
3.0039	1.3931	2.1562	3.11E-02	Seriously.lonely	Unemployed_SE	1.0808
5.7155	0.7862	7.2699	3.60E-13	Emotional.lonely	Unemployed_SE	1.0808
1.1674	0.1827	6.3905	1.65E-10	(Intercept)	No.basic.education_EE	1.1573
0.0814	0.0048	17.1120	1.21E-65	Income	No.basic.education_EE	1.1573
15.5076	3.2585	4.7591	1.94E-06	Special.welfare	No.basic.education_EE	1.1573
-10.4046	3.0728	-3.3860	7.09E-04	Payments.welfare	No.basic.education_EE	1.1573
136.1329	11.9180	11.4225	3.23E-30	Debt.assistance	No.basic.education_EE	1.1573
7.2928	0.4518	16.1432	1.27E-58	Secondary.education	No.basic.education_EE	1.1573
7.3288	0.4005	18.3005	8.21E-75	(Intercept)	No.basic.education_LS	0.7886
-11.1391	2.2539	-4.9421	7.73E-07	Excessive.drinker	No.basic.education_LS	0.7886
2.0279	0.7737	2.6209	8.77E-03	Exercise.standard	No.basic.education_LS	0.7886
2.9210	1.0290	2.8388	4.53E-03	Control.over.life	No.basic.education_LS	0.7886
7.3856	0.0029	2564.4664	0.00E+00	(Intercept)	No.basic.education_PC	13086763.3334
-15.0901	0.1524	-99.0352	0.00E+00	Death	No.basic.education_PC	13086763.3334
-5.2831	0.0298	-177.4174	0.00E+00	Removals.arriving	No.basic.education_PC	13086763.3334
0.0001	0.0000	92.4221	0.00E+00	Single.person	No.basic.education_PC	13086763.3334
0.0011	0.0000	239.4335	0.00E+00	Single.parent	No.basic.education_PC	13086763.3334
-0.0002	0.0000	-81.9534	0.00E+00	Couple.without.kids	No.basic.education_PC	13086763.3334
0.0003	0.0000	107.2928	0.00E+00	Couple.with.kids	No.basic.education_PC	13086763.3334
6.4475	0.0089	722.9839	0.00E+00	(Intercept)	No.basic.education_PE	12564611.9539
0.0506	0.0073	6.9442	3.81E-12	Enough.greenery	No.basic.education_PE	12564611.9539
0.0002	0.0000	630.1267	0.00E+00	Total_housing	No.basic.education_PE	12564611.9539
0.0104	0.0005	21.5076	1.32E-102	Age.houses	No.basic.education_PE	12564611.9539
-0.1185	0.0009	-136.1191	0.00E+00	Value.houses	No.basic.education_PE	12564611.9539
-0.0288	0.0003	-89.3475	0.00E+00	Ownership.houses	No.basic.education_PE	12564611.9539
0.0078	0.0034	2.3029	2.13E-02	Rent.houses	No.basic.education_PE	12564611.9539
-0.0460	0.0010	-44.5341	0.00E+00	Surface.houses	No.basic.education_PE	12564611.9539
10.3504	0.0437	236.8699	0.00E+00	Occupancy.overcrowded	No.basic.education_PE	12564611.9539
0.1920	0.0017	114.0001	0.00E+00	Room.houses	No.basic.education_PE	12564611.9539
-0.0004	0.0000	-57.2570	0.00E+00	Shops	No.basic.education_PE	12564611.9539
6.2322	0.1854	33.6180	9.17E-248	(Intercept)	No.basic.education_SE	0.7704
5.2818	1.6489	3.2033	1.36E-03	Seriously.lonely	No.basic.education_SE	0.7704

Table F.4 – continued from previous page

Estimate	Std..Error	z.value	Pr...z..	coeficients	data	theta
2.6428	0.9298	2.8422	4.48E-03	Emotional.lonely	No.basic.education_SE	0.7704
2.8835	0.1857	15.5253	2.34E-54	(Intercept)	High.education_EE	0.9460
0.1129	0.0051	22.0900	3.94E-108	Income	High.education_EE	0.9460
-6.8684	2.1264	-3.2301	1.24E-03	Special.welfare	High.education_EE	0.9460
138.5832	13.1342	10.5513	5.01E-26	Debt.assistance	High.education_EE	0.9460
1.6047	0.4898	3.2766	1.05E-03	Secondary.education	High.education_EE	0.9460
7.2809	0.3989	18.2511	2.03E-74	(Intercept)	High.education_LS	0.8090
-5.3950	2.6208	-2.0585	3.95E-02	Excessive.drinker	High.education_LS	0.8090
2.9450	1.5828	1.8606	6.28E-02	Heavy.drinker	High.education_LS	0.8090
3.9344	1.0001	3.9342	8.35E-05	Moves.sufficiently	High.education_LS	0.8090
-5.5829	0.9024	-6.1869	6.13E-10	Control.over.life	High.education_LS	0.8090
6.8882	0.0030	2306.8572	0.00E+00	(Intercept)	High.education_PC	16299253.2207
-11.3968	0.1481	-76.9326	0.00E+00	Death	High.education_PC	16299253.2207
-2.2351	0.0232	-96.3257	0.00E+00	Removals.arriving	High.education_PC	16299253.2207
0.0007	0.0000	465.0109	0.00E+00	Single.person	High.education_PC	16299253.2207
-0.0022	0.0000	-442.8687	0.00E+00	Single.parent	High.education_PC	16299253.2207
-0.0007	0.0000	-214.6326	0.00E+00	Couple.without.kids	High.education_PC	16299253.2207
0.0013	0.0000	426.4389	0.00E+00	Couple.with.kids	High.education_PC	16299253.2207
8.3747	0.0095	881.9655	0.00E+00	(Intercept)	High.education_PE	25308992.6168
-0.7694	0.0083	-92.3107	0.00E+00	Enough.greenery	High.education_PE	25308992.6168
0.0002	0.0000	537.1540	0.00E+00	Total_housing	High.education_PE	25308992.6168
0.0051	0.0005	10.9560	6.22E-28	Age.houses	High.education_PE	25308992.6168
0.0735	0.0007	108.0274	0.00E+00	Value.houses	High.education_PE	25308992.6168
0.0285	0.0003	82.3620	0.00E+00	Ownership.houses	High.education_PE	25308992.6168
-0.6312	0.0032	-197.7827	0.00E+00	Rent.houses	High.education_PE	25308992.6168
-0.0048	0.0012	-3.9194	8.88E-05	Surface.houses	High.education_PE	25308992.6168
-3.7003	0.0518	-71.4639	0.00E+00	Occupancy.overcrowded	High.education_PE	25308992.6168
-0.2640	0.0013	-202.3551	0.00E+00	Room.houses	High.education_PE	25308992.6168
0.0005	0.0000	71.6970	0.00E+00	Shops	High.education_PE	25308992.6168
8.2899	0.1208	68.6163	0.00E+00	(Intercept)	High.education_SE	0.7774
-4.3320	0.8224	-5.2676	1.38E-07	Seriously.lonely	High.education_SE	0.7774
5.6365	0.1212	46.4960	0.00E+00	(Intercept)	Total.crimes_SE	1.5866
2.6041	0.3250	8.0131	1.12E-15	Emotional.lonely	Total.crimes_SE	1.5866
6.1634	0.1115	55.3017	0.00E+00	(Intercept)	Total.crimes_EE	1.5766
-7.0805	1.5500	-4.5681	4.92E-06	Payments.welfare	Total.crimes_EE	1.5766
64.2083	8.8513	7.2541	4.04E-13	Debt.assistance	Total.crimes_EE	1.5766
0.5755	0.3090	1.8624	6.26E-02	Secondary.education	Total.crimes_EE	1.5766
3.7276	0.2873	12.9742	1.71E-38	(Intercept)	Total.crimes_LS	1.8230
0.8634	0.5658	1.5258	1.27E-01	Smoking	Total.crimes_LS	1.8230
-3.5198	1.7730	-1.9852	4.71E-02	Excessive.drinker	Total.crimes_LS	1.8230
7.7594	1.1430	6.7886	1.13E-11	Heavy.drinker	Total.crimes_LS	1.8230
4.7138	0.4587	10.2753	9.11E-25	Exercise.standard	Total.crimes_LS	1.8230
4.7631	0.0983	48.4420	0.00E+00	(Intercept)	Total.crimes_PC	3.0048
38.1311	5.6369	6.7646	1.34E-11	Birth	Total.crimes_PC	3.0048
5.8403	1.8165	3.2151	1.30E-03	Death	Total.crimes_PC	3.0048
3.2281	0.3748	8.6132	7.11E-18	Removals.arriving	Total.crimes_PC	3.0048
0.0004	0.0000	12.5131	6.33E-36	Single.person	Total.crimes_PC	3.0048
-0.0003	0.0001	-3.3953	6.85E-04	Couple.without.kids	Total.crimes_PC	3.0048
0.0003	0.0001	4.3805	1.18E-05	Couple.with.kids	Total.crimes_PC	3.0048
6.8577	0.1464	46.8579	0.00E+00	(Intercept)	Total.crimes_PE	4.0942
-0.8377	0.1624	-5.1600	2.47E-07	Enough.greenery	Total.crimes_PE	4.0942
0.0001	0.0000	17.1847	3.45E-66	Total_housing	Total.crimes_PE	4.0942
0.0233	0.0097	2.3930	1.67E-02	Age.houses	Total.crimes_PE	4.0942
-0.0194	0.0113	-1.7225	8.50E-02	Value.houses	Total.crimes_PE	4.0942
-6.1244	0.9338	-6.5586	5.43E-11	Occupancy.overcrowded	Total.crimes_PE	4.0942
-0.1554	0.0243	-6.3906	1.65E-10	Room.houses	Total.crimes_PE	4.0942
0.0024	0.0002	13.6965	1.07E-42	Shops	Total.crimes_PE	4.0942

F.4. PCA modelling results

The last table of Appendix A, presents the PCA modelling results (F.5). It gives the estimation, standard error, z-value, P-value, belonging concept and mental health coming and the theta for each coefficient. It is an extended description of the PCA modelling results of Figure 6.3 in Section 6.1.5.

Table F.5: Results PCA regression

Estimate	Std..Error	z.value	Pr...z..	coeficients	data	theta
5.4285	0.0283	191.6835	0.00E+00	(Intercept)	Anxiety.disorder	1.9636
-0.1747	0.0281	-6.2246	4.83E-10	Economic.environment	Anxiety.disorder	1.9636
-0.0311	0.0321	-0.9700	3.32E-01	Life.style	Anxiety.disorder	1.9636
-0.4948	0.0177	-27.8900	3.53E-171	Physical.environment	Anxiety.disorder	1.9636
0.0033	0.0274	0.1195	9.05E-01	Population.characteristics	Anxiety.disorder	1.9636
0.1014	0.0391	2.5900	9.60E-03	Social.environmnet	Anxiety.disorder	1.9636
6.3243	0.0270	234.3151	0.00E+00	(Intercept)	Burn.out	2.1440
-0.1596	0.0216	-7.3860	1.51E-13	Economic.environment	Burn.out	2.1440
-0.0173	0.0229	-0.7545	4.51E-01	Life.style	Burn.out	2.1440
-0.5641	0.0185	-30.4891	3.64E-204	Physical.environment	Burn.out	2.1440
-0.0851	0.0258	-3.2989	9.71E-04	Population.characteristics	Burn.out	2.1440
0.0524	0.0367	1.4293	1.53E-01	Social.environmnet	Burn.out	2.1440
5.8039	0.0263	220.3076	0.00E+00	(Intercept)	Depression	2.2597
-0.2195	0.0264	-8.3270	8.29E-17	Economic.environment	Depression	2.2597
0.0506	0.0287	1.7618	7.81E-02	Life.style	Depression	2.2597
-0.4364	0.0167	-26.1930	3.20E-151	Physical.environment	Depression	2.2597
0.0132	0.0232	0.5695	5.69E-01	Population.characteristics	Depression	2.2597
-0.0411	0.0372	-1.1036	2.70E-01	Social.environmnet	Depression	2.2597
6.2030	0.0259	239.6638	0.00E+00	(Intercept)	Min1.disorder	2.3327
-0.1627	0.0265	-6.1360	8.46E-10	Economic.environment	Min1.disorder	2.3327
0.0442	0.0325	1.3624	1.73E-01	Life.style	Min1.disorder	2.3327
-0.4706	0.0164	-28.7627	6.28E-182	Physical.environment	Min1.disorder	2.3327
-0.0459	0.0227	-2.0204	4.33E-02	Population.characteristics	Min1.disorder	2.3327
0.0532	0.0352	1.5110	1.31E-01	Social.environmnet	Min1.disorder	2.3327
6.4647	0.0253	255.1969	0.00E+00	(Intercept)	Not.happy	2.4315
-0.1552	0.0245	-6.3446	2.23E-10	Economic.environment	Not.happy	2.4315
0.0028	0.0224	0.1246	9.01E-01	Life.style	Not.happy	2.4315
-0.4397	0.0151	-29.0499	1.54E-185	Physical.environment	Not.happy	2.4315
-0.0752	0.0248	-3.0374	2.39E-03	Population.characteristics	Not.happy	2.4315
-0.0876	0.0323	-2.7157	6.61E-03	Social.environmnet	Not.happy	2.4315

G

Results PCA

This appendix visualizes the representation of each first PCA of all the concepts in all the mental health outcome models(Figure G.1 till G.5). This appendix adds to Section 6.1.5, and gives insight in the amount of unrepresented variance of the concepts that is modeled. The figures below show that the amount of variance that is explains differs per concept per mental health outcome. The average is around 50 percent.
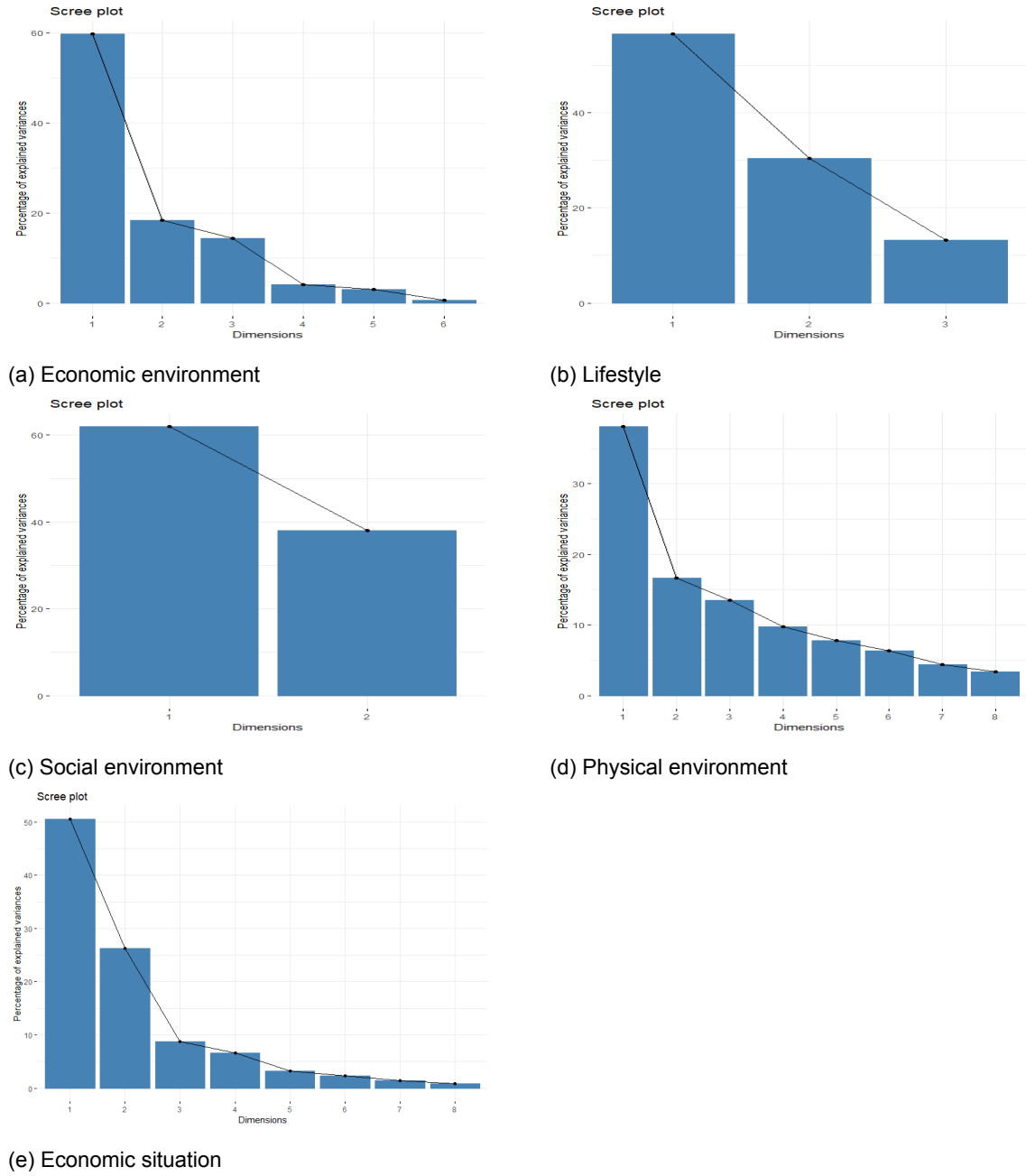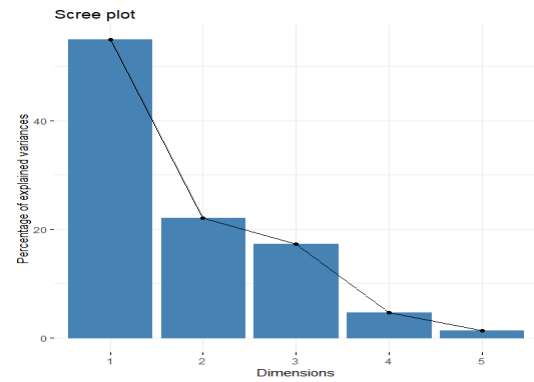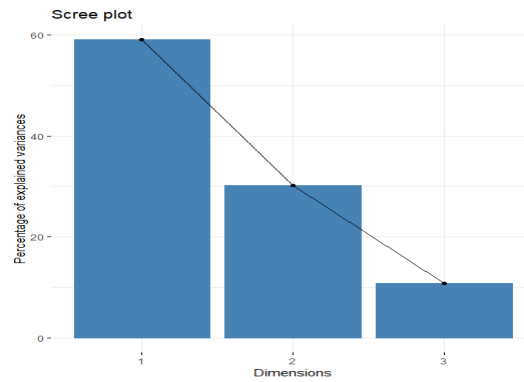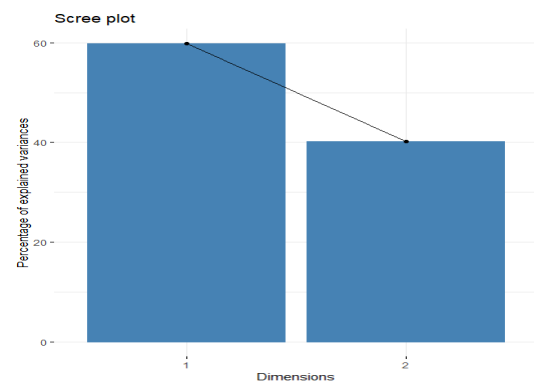
(a) Economic environment

(b) Lifestyle

(c) Social environment

(d) Physical environment

(e) Economic situation

Figure G.1: Anxiety disorder results of the PCA: total variance percentage per dimension

(a) Economic environment

(b) Lifestyle

(c) Social environment
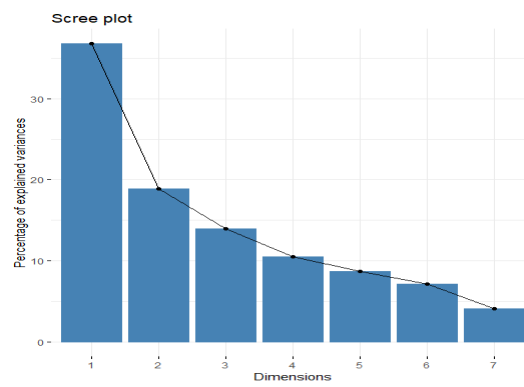
(d) Physical environment
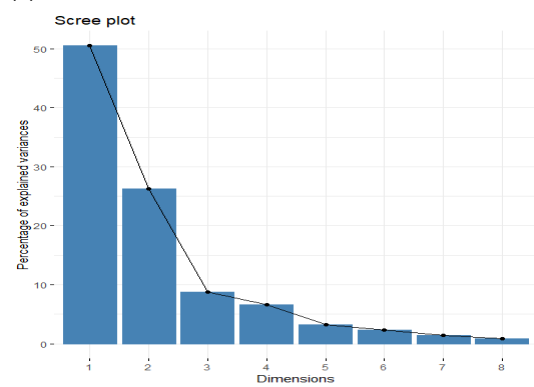
(e) Economic situation

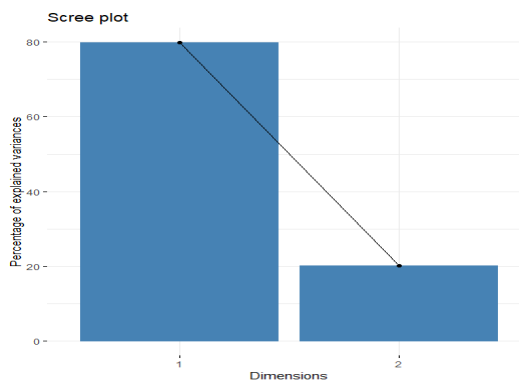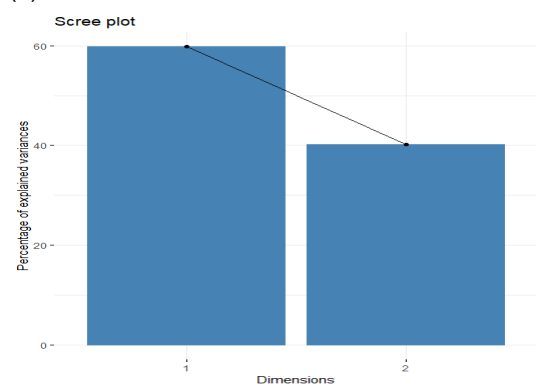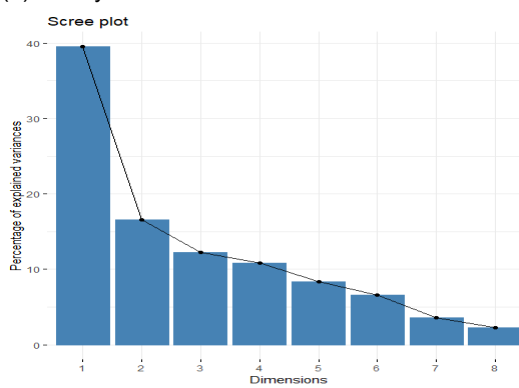Figure G.2: Burn out results of the PCA: total variance percentage per dimension

(a) Economic environment

(b) Lifestyle

(c) Social environment

(d) Physical environment

(e) Economic situation
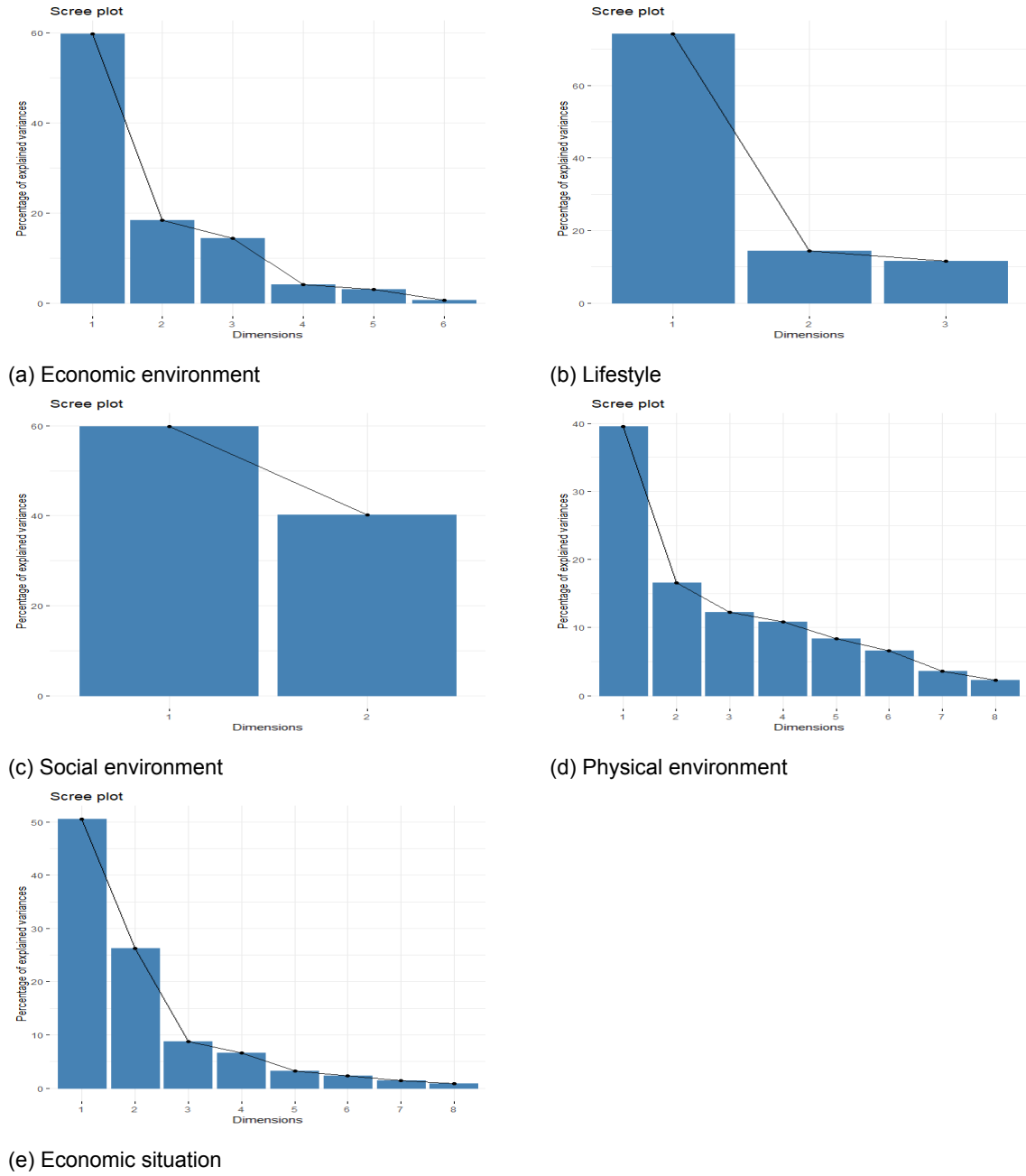
Figure G.3: Depression results of the PCA: total variance percentage per dimension
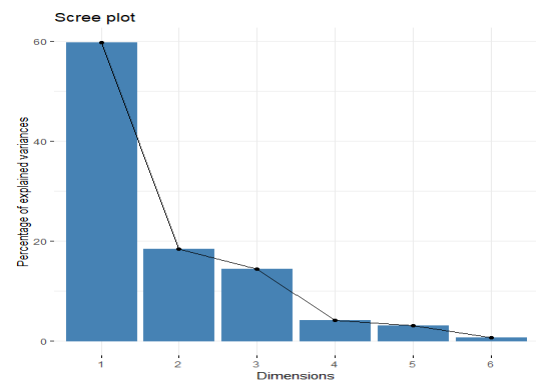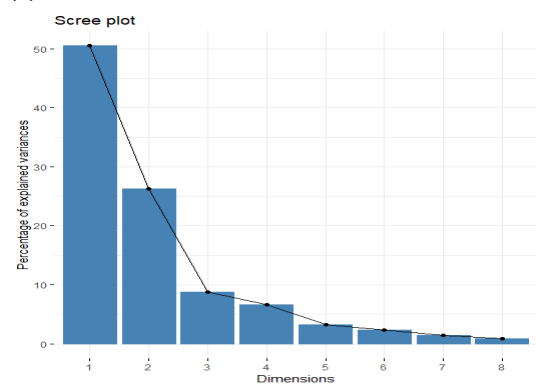
(a) Economic environment

(b) Lifestyle

(c) Social environment

(d) Physical environment

(e) Economic situation

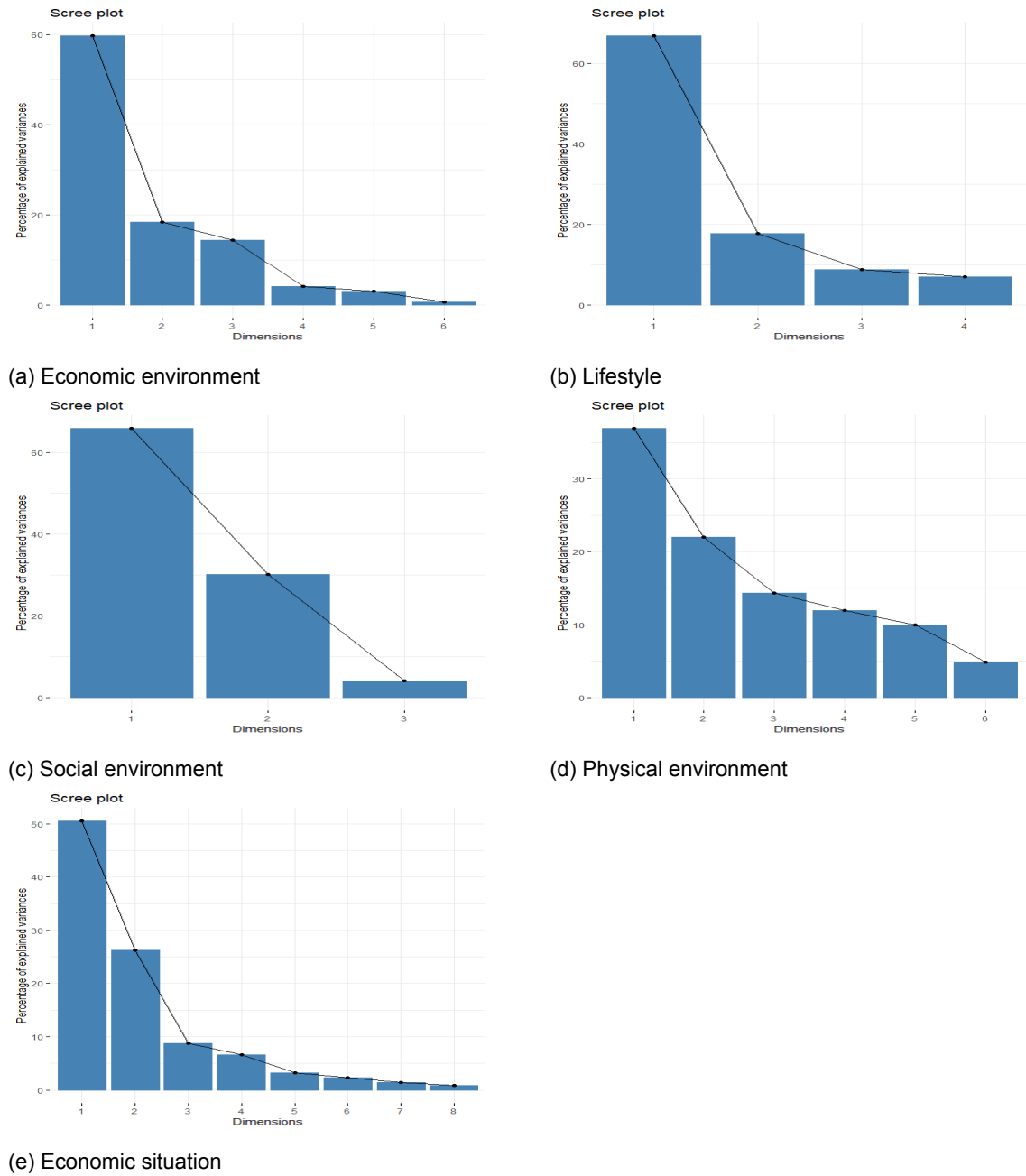Figure G.4: Min 1 disorder results of the PCA: total variance percentage per dimension
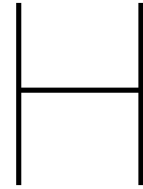
(a) Economic environment

(b) Lifestyle

(c) Social environment

(d) Physical environment

(e) Economic situation

Figure G.5: Anxiety disorder results of the PCA: total variance percentage per dimension

H

Validation

This appendix adds to the internal validation section which discusses the model fit (Section 6.2.1). It first visualizes the residuals plots (H.1) and secondly gives the train/test split results (H.2).
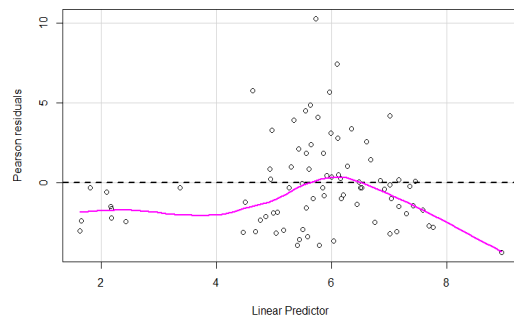
H.1. Residuals plot

The figures below show the Pearson residual plot of the holistic eight variables models (Figure H.1). For a perfect fit the pink line should follow the dotted zero boundary line, so from these plots can be concluded that the model is not a perfect fit. The figure below (Figure H.2), show the Pearson residual for the PCA regression models, this graphs are worse compared to the previous figure. This can be explained by the loss of variance through dimension reduction with the PCA.
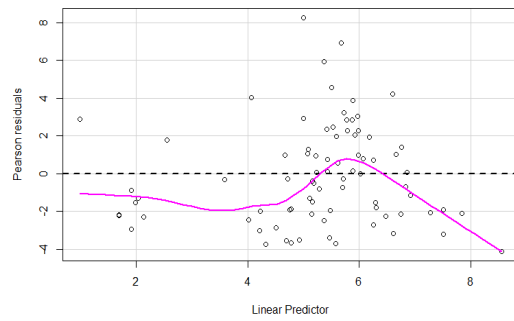
(a) Residuals plot anxiety disorder model
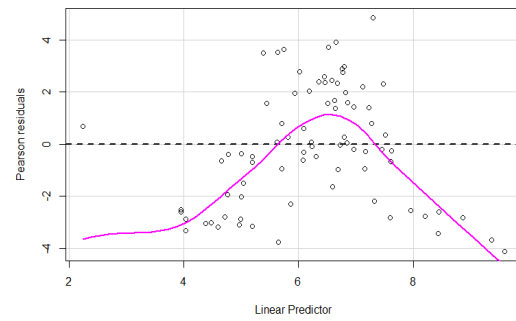
(b) Residuals plot burn-out model

(c) Residuals plot depression model

(d) Residuals plot Minimal 1 psychological disorder model

(e) Residuals plot not happy model

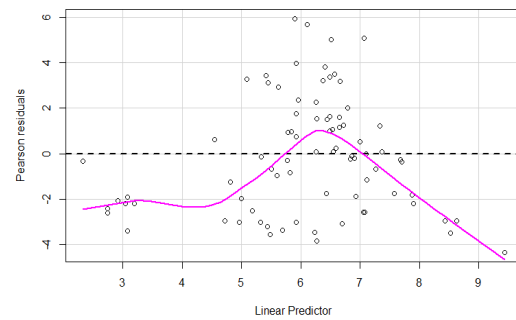Figure H.1: Plot residuals of models with the 8 highest p-values
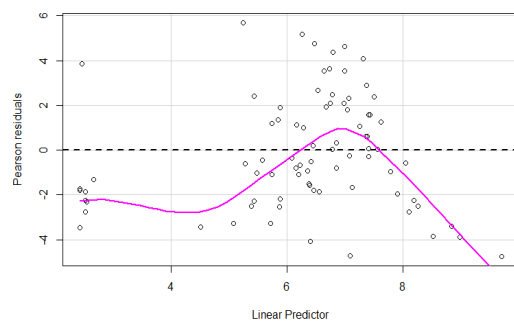
(a) Residuals plot anxiety disorder model

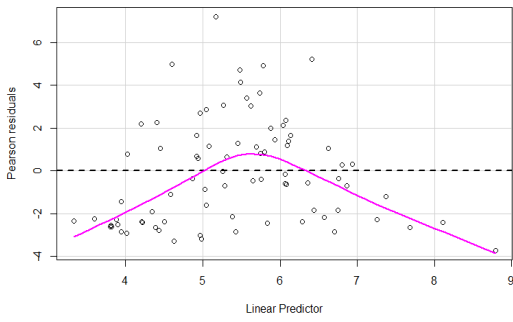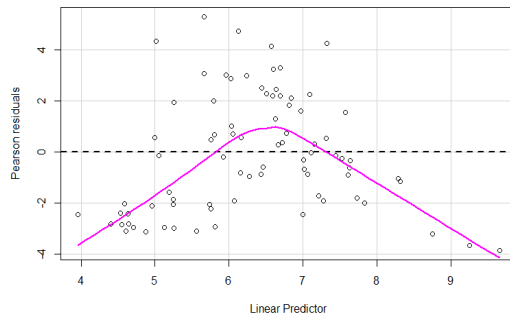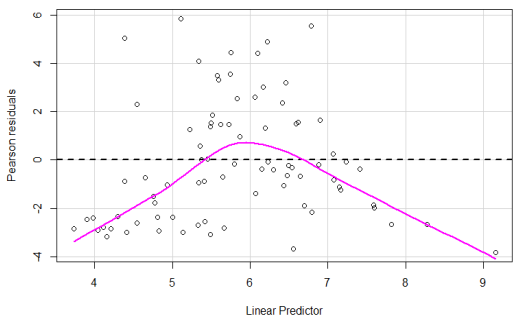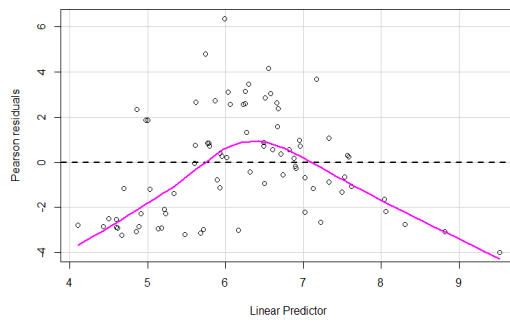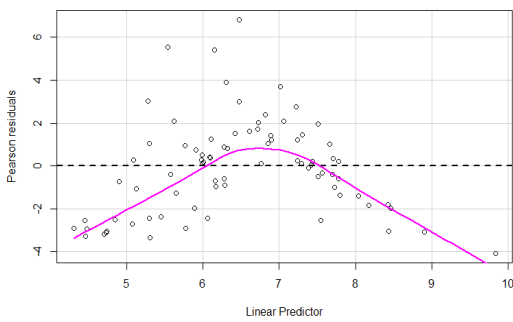(b) Residuals plot burn-out model

(c) Residuals plot depression model

(d) Residuals plot Minimal 1 psychological disorder model

(e) Residuals plot not happy model

Figure H.2: Plot residuals of models with the PCA values

H.2. train/test results

The table below (Table G.1), presents the results of the train/test prediction per mental health outcome. From this results can be concluded that the prediction differs from the real values, but show a similar proportion.

Table H.1: Tran/test predictions for the mental health outcome

Anxiety disorder		Burn out		Depression		Min 1 disorder		Not happy	
y_test	pred	y_test	pred	y_test	pred	y_test	pred	y_test	pred
205.5	156.2573	936.72	1335.188	558.11	413.7525	9.2	14.56921	9.2	11.25255
351.27	669.5513	1794.72	1809.022	887.12	426.8411	2056.05	1818.74	1673.71	1793.919
507.4	313.1633	59.16	39.27991	28.32	38.0485	428.04	456.1541	190.82	190.2145
5.75	2.558866	860.86	703.4397	68.15	84.11307	526.89	772.0678	2389.2	2009.863
959.49	1125.262	312.9	183.0735	318.4	370.2729	38.1	37.58396	2820.61	2194.57
238.92	718.7443	990.21	800.8518	945.42	939.6063	1240.65	1497.954	993.6	916.5918
33.66	66.99977	636.48	642.5683	236.24	191.8275	957.44	1263.948	442.95	410.5883
304.68	291.3671	0	1.243613	4.69	3.168758	1.12	1.491677	422.11	446.5024
275.7	789.6714	5.36	5.6569	1342	1060.67	888.8	1032.159	2013	2106.464
159.12	221.4952	3056.94	3458.214	646.4	829.1529	2037.96	2174.22	1193.4	981.4388
0.16	0.539935	1215.11	1261.939	654.29	651.931	1215.11	1104.17	1241.4	1075.726
565.6	476.4705	500.5	876.4035	475.32	818.6729	670.9	549.3489	463.23	703.5232
679.32	1290.891	1628.7	2806.914	102.94	227.861	383.04	370.7393	246.75	310.6881
581	380.9544	282	272.6467	148.08	545.1031	744.84	950.6061	167.6	134.9757
16.8	10.16925	1410	919.8579	1511.29	1286.101	0	9.505952	125.94	160.8419
148.08	304.5387	88.47	80.8033	71.76	76.41074	209.9	136.0323	2094.82	1823.224

Policy trends

This last appendix shows the policy trends of the documents that are analyzed for the policy trend analysis. It contributes to section 7.2 in the main document. The first table shows the international policy trend analyses (Table I.1). For each policy trend the belonging organization and document are mentioned. The second table summarizes the national policy analysis, for this table the same structure is used (Table I.2).

Table I.1: Policy focus international organizations

Organization	Policy focus	Document
World Health Organization	Social determinants of mental health	World Health Organization and Calouste Gulbenkian Foundation (2017)
	Social and physical health inequalities	World Health Organization and Calouste Gulbenkian Foundation (2017)
	Evidence-based practice	World Health Organization and Calouste Gulbenkian Foundation (2017), World Health Organization (2017)
	Multi-sectoral approach	World Health Organization and Calouste Gulbenkian Foundation (2017), World Health Organization (2017)
	Empowerment of persons with mental disorders and psycho-social disabilities	World Health Organization and Calouste Gulbenkian Foundation (2017)
	Collect health and socio-demographic data	World Health Organization and Calouste Gulbenkian Foundation (2017), World Health Organization (2017)
	Strengthen leadership and governance for mental health	World Health Organization (2017)
	Community based mental health	World Health Organization (2017)
	Promotion and prevention mental health	World Health Organization (2017)
European Union	Reduce health inequalities	Mackenbach (2015)
	Empower people to live healthy lives	Maeckelberghe and Mckee (2015)
	Evidence-based health policy	Rosenkötter and Bon-Martens van (2015)
	Community based mental health	Caldas De Almeida, Mateus, Frasquilho, and Parkkonen (2018)
	Acting on prevention and promotion	Caldas De Almeida et al. (2018)
	Collaboration	Caldas De Almeida et al. (2018)
	Mental health in all policies	Caldas De Almeida et al. (2018)
	Action on social determinants of mental health	Caldas De Almeida et al. (2018)
	Multi-stakeholder policy	Caldas De Almeida et al. (2018)
	Public monitoring	Caldas De Almeida et al. (2018)
OECD	Mild and moderate disorders and prevention	Hewlett and Moran (2014)
	Community care	Hewlett and Moran (2014)
	Improve mental health data	Hewlett and Moran (2014)
	Focus on prevention	Hewlett and Moran (2014)

Table I.2: Policy focus Netherlands

Organization	Policy focus	Document
OECD	Shift to community based services	Forti et al. (2014)
	Demographic determinants of mental health	Forti et al. (2014)
World Health Organization	Gaps in health outcomes and risk factors between socioeconomic groups	Kroneman et al. (2016)
	Municipality focus create possibilities for regional differences publicly funded care	Kroneman et al. (2016)
Trimbos	Multidisciplinary guidelines as strategies for quality improvement	Franx (2017)
	Transparent and evidence based guidelines	Franx (2017)
	Multilevel approach to mental health	Franx (2017)
	Partnerships between health-care providers and researchers	Franx (2017)
	Municipality connect actors for mental health prevention	Van Der Poel et al. (2014)
	First pillar of prevention is the environment	Van Der Poel et al. (2014)
	More knowledge needed of factors that predict depression	Nuijen (2017)
	More data needed	Nuijen (2017)
	Collaboration between social domain and public health	Nuijen (2017)
	Bottom-up initiative public and private sector	Nuijen (2017)

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