The effect of green facilities on university students' mental health

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Abstract

University students are disproportionately affected by some mental illness such as depression and anxiety than many other population groups. An accumulating body of research has addressed the influential factors of human mental health, and the role of green facilities in dealing with mental disorders is increasingly recognized by scholars. However, the effect of green facilities on university students' mental health has received significantly less attention than in general population. The underlying mechanisms also remain relatively unexplored. Accordingly, this research used a quantitative approach to investigate the impact of both the proportion of various green facilities around university students' living neighborhoods and their use-frequency of these green facilities on their mental health and examine the underlying mechanisms behind these two associations respectively. A survey was conducted among university students in Utrecht and Geographical Information System techniques was used to map the geography of green facilities around university students' living places. Structural equation modelling was applied to estimate the association and mechanisms. This study highlights a higher use-frequency of green facilities and more positive mental health among male university students. Also, male students tend to facilitate their physical activity level through increasing the frequency they visit green facilities in their neighborhoods, while they generally have a lower level of feeling of self-supported, they are more likely to perceive people in their living neighborhoods as less concerned with and supportive to each other. Besides, students in a financial struggle tend to experience greater depression and anxiety. After adjusted for socio-economic and demographic characteristics, no association between the proportion of green facilities in university students' living neighborhoods (which is defined in this study as a 300m buffers around university students' living place) and their symptoms of depression and anxiety have been found in this study. Although university students' use-frequency of green facilities in their neighborhoods is also found to exert no overall influence on their mental health, the beneficial effect of university students' use-frequency of green facilities in their neighborhoods upon mental health has been confirmed to operate through the intermediate mechanism—sense of community.

Keyword: university students, mental health, green, physical activity, social capital

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Contents

1. Introduction

As a prevalent and chronic condition, mental illness has been identified as a serious public health issue in all societies (Keyes, 2006). Young people are disproportionately affected by conditions such as depression and anxiety than other population groups (Biddle and Asare, 2011). Despite the fact that young adulthood is usually featured as a stage of rapid intellectual and social development, university-aged individuals are widely acknowledged as exposed to circumstances with a risk of mental disorders (Blanco et al., 2008). Most mental disorders have first begun during or shortly before university age, albeit detected later in life (Patel et al., 2007), and can be aggravated by various stressors such as academic pressures, irregular sleeping patterns in university life (Kadison, 2004). Additionally, poor mental health in young adulthood has implications for violence, substance abuse and lower academic achievements (Kessler et al, 1995; Weitzman, 2004). The stigma associated with mental illness can bring about discrimination and social exclusion, which affects one's self-esteem and disrupts social networks (Blacklock et al., 2003; Megivern et al, 2003). Therefore, the benefits of an improved understanding of mental health among university-aged students are substantial.

The past decades have witnessed an increase of studies addressing the influential factors of mental health. Widely accepted factors involve personal characteristics, physical health status, family background, social relations, and community engagement (e.g. Beyer et al., 2014; Nutsford et al., 2013). Meanwhile, the potential impacts of social and physical urban and residential circumstances have received growing attention (Guite et al., 2006). Green spaces are increasingly regarded as an important component of health-promoting environments (Nilsson et al., 2010), and an accumulating set of international studies have revealed positive effects of neighborhood green facilities on mental health of different demographical groups such as children, adults, and elderly people. For example, there are studies in inner city girls and workers that presented positive correlations between green space and a variety of psychological and emotional health (Ohta et al., 2007; Maas et al., 2009). Reported stress and quality of life are also suggested to be positively affected by the access and distance to green space (Stigsdotter et al, 2010; van den Berg et al., 2010). And a variety of the availability and use of natural environments indices has been found to be related to depression (Morita et al., 2007). Additionally, some studies putting an eye on the amount of green areas demonstrated an association between the increased amount of green facilities in the neighborhood and decreased anxiety/mode disorder (Nutsford et al., 2013).

However, the effect of green facilities on mental health in university students has received less attention than in a general population. Despite the existence of literature investigating the associations between green spaces and health, most studies evaluate its influence on physical or general health. Many include a mental health component, but propose contradictory findings (Lee and Maheswaran, 2011). Much less established is the investigation specifically on university students. As a special important population for mental health policy, understanding university students' mental health conditions can shed lights on preventing and treating mental disorders during this pivotal life period. However, the benefit of green facilities on mental health reported in general population may not be able to directly translate into university students due to the systematic difference experiences of greenery. In addition, the causal

pathways behind green facilities and mental health also remain relatively unexplored. There is generally a lack of study on whether green facilities influence mental health directly or indirectly through mediating effects. Knowing more about these would not only add to the understanding of the extent to which green facilities affect mental health of university-aged students, but also give policy some guides to invest in mental-health promotion and interventions for this crucial period in life.

Given this background, the current study aims to investigate the relationship between green facilities and mental health among a sample of university students in Utrecht. More specifically, my analysis has two main purposes: (1) to estimate the impact of both the proportion of various green facilities around university students' living neighborhoods and their use-frequency of these green facilities on their mental health; (2) to examine the underlying mechanisms of how the proportion of various green facilities around university students' living neighborhoods and their use-frequency of these green facilities influence their mental health respectively. In order to do so, Geographical Information System (GIS) techniques are used to map the geography of green facilities using the land-use databases of Netherlands. Questionnaires are developed to collect data. Structural equation modelling is then applied to examine the association between green facilities and mental health as well as the mechanisms behind.

This report consists of five chapters: introduction, literature review, research design, empirical results, as well as conclusions and discussion, organized as follows. It begins with a literature review, followed by presenting the conceptual framework and research questions. Then an overview of research methodology and the organization of data collection is outlined. Subsequent sections highlight the data analysis process and describe the empirical outcomes obtained. The final chapter presents the most important findings, conclusions, theoretical implications of the empirical outcomes, the unresolved issues as a guide for future research and policy implications of the study.

2. Literature review

This chapter is to introduce the theoretical framework of this study, providing an overview of the existing scientific knowledge relevant for the aim of this research, and to develop a conceptual framework. It is elaborated from the following five sections: (1) mental health, including the discussion about definition and measurement of mental health; (2) mental health of university students, consisting of relevant studies on students' mental health and providing a review of the relevant influential factors that have been found so far; (3) green facilities, introducing the concept of green facilities and reviewing previous studies that link green facilities with mental health; (4) influential mechanisms: the potential pathways that green facilities exert an influence on mental health; and (5) conceptual framework.

2.1. Mental health:

Definition of mental health

Mental health appears to be a key determinant of overall health. The importance of mental health is emphasized in the definition of health by the World Health Organization (WHO) as its essential constitution: "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 2005, P1). Although there remain some questions about the specific mechanisms of the relationship, it is known that mental health plays an important role in influencing physical health. Poor mental health can diminish immune functioning, leading to the development of certain illness or even premature death (WHO, 2001). Depression and anxiety are able to trigger a cascade of adverse changes in immune and endocrine functioning (Kiecolt-Glaser and Glaser, 2002) and stress has an effect on delaying wound healing (Kiecolt-Glaser et al. 1998). Mental functioning is therefore increasingly believed to possess an interrelationship with physical health and social functioning.

There are various definitions of mental health by scholars. Psychoanalyst Sigmund Freud once defined mental health as the capacity to work and to love (Freud, 1930, P101). In the World Health Report 2001, the World Health Organization introduced some concepts of mental health including "subjective well-being, perceived self-efficacy, autonomy, competence, inter-generational dependence, and self-actualization of one's intellectual and emotional potential, among others" (WHO, 2001, P5). Cultural differences, subjective assessments and competing professional theories all have the ability to affect how 'mental health' is defined. For example, some scholars are looking at the negative aspects of psychological adjustments such as depression, anxiety, negative moods, guilt etc., with a concentration on the presence or absence of mental problems (e.g., Eisenberg et al., 2007). Others tend to see mental health from a positive point of view, putting an eye on mental well-being. However, research on well-being has also fallen into two groups. Some regard mental health as a matter of happiness or more formally as a status with more positive and less negative affect and greater life satisfaction (e.g., Diener and Lucas, 2000; Bergan and McConatha, 2001). While the other group has been concentrating on more existential or humanistic conceptualizations which include positive psychological functioning, self-actualization, self-acceptance, purpose in life (e.g., Ryan and Deci, 2001)

On top of that, it is nearly not possible to put forward a comprehensive definition of mental health given all these different perspectives. Researchers have operationalized everyday mental health in a number of ways (e.g., Ettema and Schekkerman, 2015). Although it has been pointed out by some scholars (e.g. Keyes, 2006) that the absence of mental illness can be viewed as a necessary but insufficient condition for psychological well-being, however, individuals with mental illness are thought to be more sensitive to environmental factors such as the amount of recreation area, the presence of abandoned buildings, the condition of buildings (Weich et al., 2002). This research tends to investigate the impact of green facilities, as a physical environmental resource, on mental health. Therefore, I chose the definition of mental health as the presence or absence of specific symptoms of mental illness in this study.

Measurement of mental health

Over the past decades, substantial instruments have been developed to estimate mental health in different populations. There are a variety of scales assisting the measurement of mental health. Some scales measure personal mental functioning, which bear resemblance to the cognitive and affective well-being scales. Take the Warwich-Edinburgh Mental Well-Being Scale (WEMWBS) as an example, it is a measure of mental well-being proposed by Tennant et al. (2007) that consists only of positively worded items covering different aspects of positive mental health. Positive mental health is a construct that involves affect and psychological functioning of two different perspectives: the hedonic perspective and the eudaimonic perspective. The hedonic perspective concentrates on the states of happiness, pleasure attainment and pain avoidance as well as life satisfaction. In contrast, the eudaimonic perspective includes positive psychological functioning, meaning and self-actualization/acceptance. These two perspectives tend to address different questions thus complement each other (Ryan and Deci., 2001). WEMWBS scale aims to take a range of conceptualization of mental health: affective-emotional aspects, cognitive-evaluative dimensions, as well as psychological functioning into consideration. It contains 14 items covering positive affect (feelings of optimism, relaxation, cheerfulness) which refers to the hedonic aspect of mental health, as well as satisfying interpersonal relationships and positive psychological functioning (feelings of being loved and closed to other people, energy, clear thinking, competence to deal with problems and feeling of usefulness), referring to the eudaimonic aspect of mental health (Tennant et al., 2007).

Other scales, such as the Kessler Psychological Distress Scale (K10) (Furukawa et al., 2003), the five-item mental health index (MHI-5) (Rumpf et al., 2001) or Hopkins Symptom Checklist (SCL) (Strand et al., 2003), contrast the abovementioned mental well-being scales and estimate psychological distress in populations, mainly concentrating on the symptoms of mental disorders such as depression and anxiety, and examining the presence and the severity extent of corresponding symptoms. The SCL, for example, is a widely known, multidimension in nature and self-administered instrument. It has been used in several versions with different length of items ranging from five to nighty on a variety of symptoms such as depression, anxiety, obsessive compulsive, and interpersonal sensitivity (Strand et al., 2003).

2.2. Mental health of university students:

The majority of studies about university students' mental health focus on the mental disorders students are going through. Common noticed mental problems with rising prevalence and severity among university student population these years include depression, anxiety, eating disorders, self-harm, obsessive compulsive disorder, and psychotic disorders (e.g. Warwick et al., 2008; Megivern et al., 2003; Collins and Mowbray, 2005; Storrie et al, 2010). Eisenberg and his colleagues (2007) did a research on measuring the prevalence and correlates of depression, anxiety, and suicidality issues of university students. It was discovered that the prevalence of depression and anxiety disorders was 15.6% and 13% respectively for undergraduates and graduate students, and 2% of university students reported the attempt of committing suicide. Besides, some researchers suggest measuring the functional impairments as it has the capacity to distinguish disorders that are mild or self-limiting from those which can affect functioning more severely, thus benefit the assessment of severity of mental disorders (Mechanic, 2003; Kessler et al., 2005). Therefore, in Eisenberg and his colleagues' study, the impairment in university students' academic activities that are related to mental health were also included.

Despite that mental health issues among students attract increasingly attention by society, university students are often unwilling to seek for help due to the discrimination and exclusion caused by the stigma of mental illness (Blacklock et al., 2003; Megivern et al, 2003). A cross-sectional study conducted by Zivin et al. (2009) measured the persistence of some mental problems: anxiety, depression, eating disorders, self-injury as well as suicidal ideation, and found out that, although most of university students with possible mental disorders perceived the need for mediation or therapy, most of them didn't receive any treatment.

This study looks at the mental health of university students. As mentioned previously, mental health is defined in this study in terms of the presence or absence of some symptoms of mental illness. Due to practical reasons and the space constraints in the survey, it is not possible to exclusively involve all mental disorders among university students. Consequently, according to previous studies (e.g. Eisenberg et al., 2007; Warwick et al., 2008), I have sampled two highly representative disorders: depression and anxiety.

Mental health has been shown to vary across certain demographic and socio-economic categories. Even within the university population some subgroups have a higher tendency to suffer from a significantly higher prevalence of mental problems than others (Hunt and Eisenberg, 2010). For example, there have been studies suggesting that male undergraduates are facing a higher risk of committing suicide (e.g., Silverman et al, 1997), while females tend to screen more positively for anxiety and for depression (e.g., Eisenberg et al 2007). However, some contrasting findings have also indicated that females typically have higher prevalence of depression (e.g. Kessler et al., 1993). Lower socioeconomic status has known to be a risk factor for mental health problems in general population (Yu and Williams, 1999), which is also consistent with what some studies have found that university students under financial struggles report a higher risk of depression and anxiety symptoms (e.g., Eisenberg et al, 2007). Apart from gender and socioeconomic status, housing conditions, individuals' lifestyle correlates such as smoking and drinking

status have also been discovered to associate with mental health (Byles et al., 2012; Feng et al., 2013; Astell-Burt et al., 2013).

2.3. Green facilities:

Exploring the relationship between neighborhood characteristics and individual mental health has been a long tradition of research (Macintyre and Ellaway, 2000). This type of research primarily concentrates on sociological and psychological elements including social integration, social capital, social interactions, and sense of community (Gee and Payne-Sturges, 2004). Researches have demonstrated that, geographical area-based social cohesion and informal social control as an aspect of social capital, can be converted into a sense of freedom and safety which is not only profitable for children's and young adults' healthy affective and cognitive development (Ross et al., 2000; Davis, 1998; Sampson et al., 1997) but also of large importance for adults and senior citizens' mental health and emotional well-being (Harris et al., 1999a, b; Lindström et al., 2003; Klinenberg, 2002). Therefore, increasing the extent of social integration, bridging or enhancing social ties with others, and building social capital can be beneficial for mental health (Almedom, 2005). Nevertheless, the significance of physical environment in the neighborhood on influencing mental health is increasingly recognized. An emerging body of evidence confirms this association upon which the most significant factors exerting independently are neighbor noise, neighborhood nuisance and crime, over-crowding, community facilities, and green space (e.g. Chu et al., 2004). Physical environment can be both a source of stress and a resource assisting individuals to deal with mental illness (Diez-Roux, 1998; Van den Berg et al., 2010).

One potentially powerful physical neighborhood resource that has attracted much attention from researchers and policy makers is green facilities. The term 'green facilities' used here is equivalent to other terms like green spaces, green areas, green environments, green settings and green infrastructure in a variety of literatures. Green facilities can be regarded to "comprise of all natural, semi-natural and artificial networks of multifunctional ecological systems within, around and between urban areas, at all spatial scales" (Tzoulas et al., 2007). All urban green, agricultural green, forests, and nature conservation areas can be considered as green facilities. It stresses both the quality and quantity of urban and peri-urban green spaces, their multifunctional roles, and the interaction with residents (Turner, 1996; Rudlin and Falk, 1999; Sandström, 2002; van der Ryn and Cowan, 1996). Green facilities provide residents with a recreational and social communal place to escape from stresses and strains of personal lives. There are self-report studies about people's favorite places suggesting that particular neighborhood places, mainly green settings, are where people visit for emotional release and also restorative experiences (Korpela, 1992; Korpela and Hartig, 1996).

As green facilities are widely viewed as being linked to mental health, some studies have been conducted to examine what effect green facilities in the neighborhood have upon mental health. Using GIS techniques, Nutsford et al. (2013) carried out a study in Auckland to investigate the associations between the proximity to and the proportion of urban green spaces and human mental health. They found that better access to green space was related to a decrease in anxiety/mood disorder treatment counts.

Particularly, in a boarder neighborhood (in this study referring to 3 km buffer of population-weighted MB centroid), the higher the proportion of green space and proximity to useable green space, the lower the level of anxiety/mood disorder treatment. This finding to certain extent confirms what de Vries et al. (2003), Maas et al. (2006) and Van den Berg et al. (2010) found in their studies, that the area of green space within 3 km buffer was positively associated with mental and general health. Moreover, the positive association between mental health and the proportion of green space within 3 km were revealed in this study while no relationship between the proportion within 300 m buffers and mental health was suggested. This is different from what Maas et al. (2009) found in the Netherlands, the proportion of green space within 1 km had a stronger correlation with anxiety and depression than the proportion within 3 km. Yet the authors also argued that the strength of this relation tended to decrease from strongest in slightly urban areas to not apparent in very highly urban areas.

Not only the association between mental health and the objectively measured amount and proximity to green facilities were examined, there are also several studies focusing on people's use and subjective perception of green facilities. Nielsen and Hansen (2007) investigated the association between the use of green areas and health from a Danish survey. They discovered that although the shorter distance to green areas was connected with health indicators, the frequency of visits could not explain the effects of green area on health indicators. However, in their study, the only indicator selected for mental health is experienced stress. Therefore, there may be different outcomes when using other indicators such as depression or anxiety. Another study carried out by Sugiyama et al. (2008) put an eye on the relationship between the perceived neighborhood 'greenness' and perceived mental health. Derived from the Neighborhood Environment Walkability Scale, five questions containing the access to a park or a nature reserve, presence of greenery as well as pleasant natural features, access to a cycle path or a pavement, and presence of green cover along pavements were asked to identify the perceived greenness of a neighborhood. It was found that the perceived neighborhood greenness had a stronger positive association with mental health than physical health. People who perceived their neighborhoods as higher green had a better level of mental health than those who had a lower green perception of neighborhood.

Moreover, some studies have been looking into different angles. Astell-Burt et al. (2013) conducted a longitudinal study on the association between green space and mental health across the life course. Their findings suggested that this association followed gender-specific trajectories. For males, the mental health benefits from green space appeared in early adulthood whereas for women green space tended to have an association with mental health only until mid-40s. Besides, another study carried out in England explored how moving to a greener or less green neighborhood would affect mental health over time. People who moved to greener neighborhoods experienced better mental health in the postmove years, whereas those who moved to less green areas had a significantly worse mental health in the year before moving, then their mental status gradually returned to original baseline after the move (Alcock et al., 2014).

This research is interested in studying the green facilities inside the neighborhood, neighborhood is a spatially and socially constituted place. The literature reveals that large divergences exist on the way how

neighborhood is defined and what neighborhood size should be used in geographical studies. The concept of neighborhood is usually operationalized differently across studies as well. For example, Brower (1996) described the 'neighborhood area' as consisting of a group of house area with the commonly shared residential areas. Galster (2001) defined neighborhood as a 'bundle of spatially based attributes associated with clusters of residences, sometimes in conjunction with other land uses.'' (Galster, 2001, p. 2112). There are different recommendations or choices of geographic scale of green facilities measurement in the neighborhood. For example, Natural England, a Government agency, proposed a recommendation that all residents are supposed to access green facilities within a radius of 300m buffer from home (Coombes et al., 2010). Besides, Dutch recreational counsel raised that starting from the recreational quality characteristics, more recreational space within a 500m radius of the home represents a higher quality of the recreational environment (Wendel-Vos et al., 2004). For practical use, however, the definition and the choice of geographic scale of a neighborhood is commonly restricted immediately by the data we already possess and are able to collect.

2.4. Influential mechanisms:

The abovementioned findings have demonstrated the association between mental health and natural or 'green' environments. Generally speaking, the majority of the literatures claim that no matter the objectively measured higher amount of green facilities in the neighbourhood or the subjective higher frequency of visits to green facilities, green facilities in the living environment are positively related to people's mental health. However, from these studies the way in which green facilities exert a beneficial effect on mental health is still unclear. There are four mechanisms: direct exposure, physical activity, social ties, and sense of community, that might help explain the association.

2.4.1 Direct exposure

It can be argued that restorative experiences of nature, which trigger enhanced psychological restoration simply by virtue of immersion within green spaces (Kaplan and Kaplan, 1989; Sternberg, 2009; Ulrich, 1983), play a role in the relation between green facilities and mental health.

Why might exposure to green settings serve physiological, emotional, and attentional restoration? Two theories have been proposed to provide some thoughts. Attention Restoration Theory (ART) asserts that spending time in natural environments can influence one's mood and ability to concentrate, namely, experiences in natural settings have the capacity to enable the recovery from mental fatigue and to restore directed attention (Kaplan and Kaplan, 1989; Kaplan, 1995). According to ART, directed attention is under voluntary control and central to achieving focus. By using inhibition mechanisms, it is able to control distractions. As directed attention requires effort, it is sensitive to fatigue and can be increasingly ineffective with prolonged use. Directed attention fatigue is a key source of ineffectiveness and human error. The prolonged and intense mental effort contributes to directed attention fatigue, the occurrence of which generates individual's experience of a condition called mental fatigue. Therefore, in order to achieve recovery from mental fatigue, it is essential to relax directed attention so to restore effectiveness.

The conditions for acquiring recovery from mental fatigue described by ART can be found in a restorative environment which has four components: being away, fascination, extent, and compatibilities (Kaplan, 1995). Green settings are considered to meet all these four requirements. 'Being away' means to keep oneself away from the activities that require directed attention. It doesn't have to be a physical transformation, but essentially a conceptual shift, freeing the mind from mental fatigue. Green settings are always regarded as an ideal place for 'being away'. Due to the ability of providing extra restorative chances, green settings with easy accessibility help people relax their directed attentions. 'Fascination' is a term used to substitute involuntary attention. It is actually a core component of restorative settings, which shows up in various situations that interest people. Types of fascination are usually divided along 'soft-hard' dimension. Hard fascination can be found in a car racing which utterly draws one's attention, while nature is involved with some fascinating objects identified as 'soft' fascinations such as sunshine, clouds, and sunsets etc. (Herzog et al., 1997) which allows reflection and benefits the recovery of attention restoration. 'Extent' is critical for an environment, because the environment should possess a rich and coherent content to establish another world and have enough to reflect to fill one's mind. Extent does not necessarily refer to a large land of green, it is more of a conceptual thing. A small green park can also provide a sense of extent with paths or vegetation. 'compatibility' means that the environment should be consistent with one's goals and preferences. Green settings are scored unusually high on compatibility. It might be because being active in natural environments required less mental effort than in civilised environment (Cawte, 1967). Self-reported studies have revealed as well that green spaces are people's favourite places for emotional release and restoration experiences (Korpela, 1992; Korpela and Hartig, 1996), showing people's preferences to green spaces.

The other theory on restorative effects of nature proposed by Ulrich (1983) emphasizes the physiological or emotional changes that occur while viewing a scene after a challenge or threat. Ulrich (1983) argued that psychophysiological stress recovery could be supported by perceiving particular qualities and contents in a scene. Natural features such as trees, bushes, and grass can assist a return of autonomic 'arousal', which is a physiological and psychological state of sense organs stimulated to a point of perception, including many different neural systems (Pfaff, 2006), to more moderate levels by provoking positive emotions, maintaining unvigilant attention, and constraining negative thoughts (Shapiro et al., 2001). Ulrich assumed an evolutionary basis for restorative responses to some green settings derived from a view of human as biologically responding positively to environmental features.

Although there are some similarities, the assumptions of Ulrich's theory of restoration differs from Kaplans' ART in some ways. First, the basic response to green settings assumed in Ulrich's theory is affective instead of cognitive. Besides, Ulrich paid more attention on physiological and emotional aspects of response to a challenge or a threat, while ART is more concerned about the attention fatigue during sustained daily activities. Last, Ulrich believed that restoration was acquired from the reduction of arousal rather than the regaining of direct attention (Hartig et al., 1991). From Ulrich's point of view, natural setting is regarded as a not stressful incentive that evokes positive emotions and releases negatively toned emotions, thus displaying a calming power. Following these emotional responses, individuals tend to show a reduction in neurophysiological arousal and an extended and prolonged interest in nature settings. To sum up, these two theories cope with different antecedent condition and concentrate on different

restoration outcomes. This theory along with ART tend to complement each other with in terms of the antecedents of restoration experiences. Sometimes the antecedent condition of Ulrich's theory, physiological arousal and negative emotions of stress, and the antecedent condition of ART, mental fatigue, may occur respectively alone sometimes, but in some circumstances, they would show up together with some forms of causal relations (Cohen, 1978; Kaplan, 1995).

A growing body of research has empirically associated green facilities with promoting attention restoration and reducing stress, thus contributing to a higher level of mental health. For instance, Hartig et al. (2003) did a comparison study on psychophysiological stress recovery and directed attention restoration in natural and urban field settings from a randomly assigned young adults. After the assigned tasks, participants who spent their time exposed to green settings experienced a more rapidly declined diastolic blood pressure, a greater stress reduction, a slightly improved performance on attentional tests, an increased positive affect and a decreased anger compared with staying in the urban setting. This study indicated the beneficial effect of green facilities on public health outcomes. Additionally, Tennessen and Cimprich (1995) studied the possible restorative benefits of a natural view from a college dormitory and found that university students with less natural views tended to rate themselves lower on attention functioning and reported a more negative or depressed mood. Beyer and her colleagues (2014) examined the association of exposure to neighbourhood green facilities and mental health from a population-level perspective using the survey of the health in Wisconsin. When some confounding factors were controlled, a higher level of exposure to green facilities in the neighbourhood was found to correspond to lower depression, anxiety, and stress.

2.4.2 Physical activity

Another possible mechanism behind the association between green facilities and mental health is the mediating effect of physical activities. Physical activity simply means the movement of body that consumes energy (Caspersen and Christenson, 1985). Walking, running, cycling, playing sports, gardening, and doing domestic work all are forms of being active. It is regarded to have three intensity levels depending on the heart beating rates and breathe: light, moderate and vigorous (Levine, 2008). Physical activity usually includes commuting activities, leisure time activities, household activities, and activities at work and school (Caspersen and Christenson, 1985).

It is hypothesized that green facilities in the living environment may invite people to be more physically active (Tzoulas et al., 2007). Literature demonstrates that people prefer to conduct physical activity in aesthetically appealing environments (Giles-Corti and Donovan, 2002; Pikora et al., 2003; Sallis et al., 1998; Kamphuis et al., 2007). Green environment is considered as more appealing than built-up environment (Van den Berg et al., 2003). Accordingly, compared to other urban environments, green environment is more likely to stimulate people to conduct physical activities like running or jogging, or to choose walking and cycling as a mode of transport (Taylor et al., 1998; Edwards and Tsouros, 2006). Indeed, theoretical and empirical evidence shows that the presence of green facilities can facilitate physical activity such as recreational walking and sports. Pikora et al. (2003) concluded that based on available literature, an

attractive streetscape which usually referred to trees, lawns, urban parks, gardens as well as diverse natural sights was an important feature that associated with walking and cycling. A study carried out by Ellaway et al. (2005) also found that in the neighborhood with high levels of greenery, residents were over three times likely to be more physically active. In addition, there is evidence showing the association between levels of physical activity and proximity of neighborhood green facilities. Coombes et al. (2010) examined the association between objectively measured accessibility to green space and levels of physical activity and found that residents who lived closer to green spaces were more likely to meet guideline physical activity levels than those who lived further from green spaces.

Besides the fact that green facilities in the neighborhood can provide an incentive to be more physically active, it may also drive people to spend longer period of time outdoors. There is evidence showing that people who walk or jog in green environments tend to be more distracted from fatigue or other signals of physical symptoms after an active period (Pennebaker and Lightner, 1980). Research by Pretty et al. (2007) investigated green exercise and found out that people who participated in outdoor exercise program tended to complete their program more often than those who attended indoor exercise program. These studies have revealed that compared to indoor environment, people are inclined to spend more time in physical activity in green areas.

On the other hand, regular physical activity is perceived to be related to better mental health (Bauman, 2004; Hamer et al., 2009). Studies applying various methodologies have shown association between undertaking physical activity and improvement in mental health among diverse populations (Pate et al., 1995; Goodwin, 2003; Hassmén et al., 2000; Schmitz et al., 2004; Hamer et al., 2009). For example, a study among a representative sample of men and women from the Scottish Health Surveys indicated that a minimal physical activity level of 20 min/week would contribute to mental health benefits while there was a dose-response pattern found with a higher risk of reduction on psychological distress at higher volume or intensity of physical activity (Hamer et al., 2009). Hassmén and his colleges conducted a population study in Finland and found out a coherent association between physical activity and psychological well-being. People who exercised more frequently had a better perception of their health and fitness, and those who exercised twice a week or more reported a higher sense of social integration (Hassmén et al., 2000). Moreover, literature shows inverse association between physical activity and incident depression (Brown et al., 2005). Research by Babyak et al. (2000) demonstrated that there was a significant improvement in mental condition of people diagnosed with depression who were undergoing an aerobic-exercise intervention than those people who were receiving psychotropic treatment. Other evidence also revealed a connection between reduced activity and emerging depression (van Gool et al., 2003).

Additionally, an accumulating body of studies has indicated that the benefits of physical activity can be amplified among people who have access to green spaces (Bodin and Hartig, 2003; Hug et al., 2009; Pretty et al., 2005; Thompson Coon et al., 2011). A field experiment about running in green and built-up environment carried out by Bodin and Hartig (2003) demonstrated that people preferred to run in parks over built-up environment. Compared with built-up environment, parks could promote runner's mental restoration to a greater extent. Hug et al. (2009) in their survey of a fitness centers members in Zurich

also found that outdoor exercises were rated as more restorative than exercises in indoor settings. Thompson Coon et al. (2011) did a systematic review on comparing the effects on mental health of participating physical activity in natural settings with physical activity indoors. In comparison with indoor exercises, physical activity in green environments was related to higher feelings of revitalization and positive engagement, reductions in some mental illness symptoms such as tension, depression, and confusion. Therefore, activities in greener areas may have greater mental health returns than same activities in non-green areas.

2.4.3 Social ties

Social ties are another potential mediating factor behind the association between green facilities and mental health. Green facilities are expected to exert a direct impact on individual's social ties and then indirectly influence individual's mental health status via the link between social ties and mental health.

Several terms such as social contacts, social support, social networks, social bonds have been adopted in the literature about the health benefits of social relationships (Berkman et al., 2000; Maas et al., 2008). For my purposes in this paper, social ties are preferred over all these other terms. Here it refers to both social contacts and social support. Social contacts include contacts with other people from 'primary' and 'secondary' groups, in which 'primary group' mainly refers to family members, relatives and friends sharing intimate or strong bonds, while 'secondary group' tend to be housemates, neighbors or encounters that shares less personal knowledges. Social support includes emotional, informational, and instrumental assistance from others (House et al., 1985). Emotional assistance means the love, caring, encouragement and sympathy etc. emotional support from others. Informational assistance is the advice or guides from others to help solve problems. Instrumental assistance refers to help solve problems by providing behavioral or material support (Thoits, 2011).

Social ties are widely recognized as having a salutary impact on mental health. Substantial evidence has revealed that individuals that are actively involved in communities or socially engaged with others are mentally healthier (Kawachi and Berkman, 2001; Leyden, 2003). Research has also been conducted to explore how social ties actually work on exerting an influence on mental health. Seven mechanisms that have been discussed most frequently in the literature were proposed: social influence/social comparison, social control, role-based purpose and meaning (mattering), self-esteem, sense of control, belonging and companionship, and perceived support availability. As a pathway from social ties to mental health, 'social influence' or 'social comparison' refers to that one usually acquires normative and behavioral guidance through comparing with others in one's reference groups (Marsden and Friedkin 1994), which can be damaging or protective for mental health depending on the reference groups (Thoits, 2011). 'Social control' means the behaviors that social network members explicitly attempt to monitor, remind, encourage, persuade, and pressure someone (Thoits, 2011). Social control can help regulate the behavioral changes presaging some mental disorders like distress and anxiety, and interpret the individual's mental health symptoms as serious enough and pressure one to seek for professional treatment (Pescosolido et al., 1998; Thoits, 2011). 'Behavioral guidance, purpose, and meaning

(mattering)' are usually derived from people's role expectation—who we are to others in our social ties (Rosenberg and McCullough, 1981; Thoits, 2011), which has positive effect on mental well-being and guard against anxiety etc. (Berkman et al., 2000; Brissette et al., 2000; Cohen, 2004; Taylor and Turner, 2001; Umberson and Montez, 2010). 'Self-esteem' is another mechanism that originated from the role identities represented by social ties. 'Self-esteem' or 'self-worth' can be positively or negatively impacted by self-evaluations in role domains (Rosenberg et al., 1995). And more 'self-esteem' is associated with high levels of life satisfaction and happiness and lower levels of depression, anxiety, and distress (Baumeister et al., 2003; Taylor and Stanton, 2007; Thoits, 2003; Turner and Lloyd, 1999; Turner and Roszell, 1994). 'Sense of control' is also likely to be generated by people's role expectation and performance (Thoits, 2011). It can help sustain one's confidence in facing new challenges thereby is related to lower levels of depression and anxiety (Mirowsky and Ross, 2003; Taylor and Stanton, 2007; Turner and Lloyd, 1999; Turner and Roszell, 1994).

A Sense of 'belonging and companionship' is originated from the connections to other people on which social ties are based (Barrera, 2000; Rook and Underwood, 2000). Belonging and companionship can positively improve mental well-being while lacking belonging and companionship is usually related to depression, anxiety (Rook and Underwood, 2000; Cacioppo et al., 2002; Stroebe and Stroebe, 1996). Finally, also importantly, 'perceived social support'. Social contacts are like conduits of social support (Lin and Wescott, 1991). People usually obtain demonstrations of love, caring, encouragement and sympathy, useful information and advice from our ordinary daily social activities with their family members, friends, neighbors and others. Routine or everyday social support including emotional, informational, and instrumental support has positive effects on mental health themselves and can also help maintain self-esteem, a sense of control, a sense of belonging and companionship etc., thereby indirectly and positively affecting psychological well-being (Thoits, 2011). However, there is a divergence in literature that whether social support should be considered as a mechanism linking social ties to mental health or view the effect of social support on mental health as through entirely different mechanism from social contacts (Berkman et al., 2000; Cohen, 2004; Brissette et al. 2000). For instance, Cohen (2004) proposed that social support was the psychological and material resources acquired from social contacts that helped individuals to deal with stress, while social contacts took effects regardless of whether stress existed or not. Nevertheless, the association between social support and mental health shall not be denied.

Theoretical and empirical studies have been conducted to investigate the link between social ties and mental health. Kawachi and Berkman (2001) did a review on the literature about social ties and mental health and discussed how social ties positively influenced mental health from the view of the two causal models—the main effect model and the stress-buffering model. An empirical study performed by Uchino et al. (2001) examined the social relationships and mental health of 133 young and older adults. They found that the number of supportive ties benefited psychological outcomes while aversive ties indicated lower levels of mental health status, which is in line with some previous research (Rook and Pietromonaco, 1987). From an adverse point of view, Cornwell and Waite (2009) assessed the deleterious impact of social disconnectedness (e.g., small social network) and perceived isolation (e.g., perceived lack of social support) on older adults' mental health. Results showed that both social disconnectedness and perceived isolation

were related to worse mental health, on both self-rated mental health scale and depression symptom scale.

On the other hand, evidence suggests that green features in the neighborhoods can enhance socials ties (Sullivan et al., 2004; Kim and Kaplan, 2004). Meeting opportunities are important for people to establish relationships with neighbors thereby building social ties (Völker et al., 2007). Places like parks, recreational areas and squares are usually where social contacts between neighbors occur (Völker et al., 2007). The presence of green facilities is more likely to attract residents to outdoor spaces than non-green common spaces because they are more enjoyable and can provide shadow, privacy, or sound buffering from surrounding environment, thus contributing to more frequent contacts among people from 'primary' and 'secondary' groups (Coley et al., 1997). In Chicago, the same research group conducted three related studies. First, they explored the relationship between the use of public areas and the presence of trees and found that the presence of trees contributed to a higher possibility in using these public areas (Coley et al., 1997). Then, based on the finding, they conducted another study to examine the effect of neighborhood greenery on social ties and demonstrated that there was a positive connection between the levels of neighborhood vegetation and the strength of neighborhood social ties (Kuo et al., 1998). In the third study, they put their eyes on older adults and investigated the association between their exposure to green public areas and their social integration level and found a modest relationship (Kweon et al., 1998). Overall, these studies provided an indication of a positive association of social ties with the presence of green public facilities (Coley et al., 1997; Kuo et al., 1998; Kweon et al., 1998). However, these studies were performed in highly deprived urban areas with scarce green elements. It is unknown whether this association can apply to other richer and greener neighborhoods.

2.4.4 Sense of community

Sense of community has also been hypothesized as a possible mechanism explaining the relationship between green facilities and mental health. McMillan and Chavis (1986) defined sense of community as "a feeling that members have of belonging, a feeling that members matter to one another and to the group, and a shared faith that members' needs will be met through their commitment to be together." (McMillan and Chavis, 1986, p.9).

According to the literature on sense of community in terms of physical aspects of neighborhood, sense of community consists of four domains: community attachment, bonds with others, community identity, and pedestrianism (Kim and Kaplan, 2004). 'Community attachment' expresses residents' feeling at home or belonging to the community (Kim and Kaplan, 2004), including residents' community satisfaction (Hummon, 1992; Zaff and Devlin, 1998), sense of connectedness (Giuliani, 1991; Lalli, 1992), sense of ownership (Hummon, 1992), and long-term integration (Goudy, 1982). 'Community identity' refers to the personal and public identifications of the community which can impact residents' personal and group identity (Kim and Kaplan, 2004). Community identity is usually unique and distinctive, continuous, significant, compatible, and cohesive (Twigger-Ross and Uzzell, 1996; Giuliani, 1991; Devine-Wright and Lyons, 1997; Robinson and Wilkinson, 1995). 'Pedestrianism' implies the access for local exploration in

the neighborhood, consisting of walkability, pedestrian propinquity, public transit, and pedestrian-scale and streetside activity (Kim and Kaplan, 2004).

Besides providing meeting chances, green facilities play an important role in promoting residents' sense of community. Studies argue that natural features and green open spaces significantly contribute to these four domains of sense of community (Kim and Kaplan, 2004; Flap and Völker, 2005; Pretty et al., 1994; Prezza et al., 2001). Kim and Kaplan (2004) did a comparative study on examining four domains of sense of community in two different neighborhood community, they found that the residents of the neighborhood with a rich variety of natural features and green open spaces expressed stronger community attachment and sense of identity with the community, and the green features within the neighborhood played an important role in increasing residents' bonds with each other and facilitating pedestrianism. Arnberger and Eder (2012) examined the impact of green space on residents' community attachment and suggested that the perceived supply and quality of green space were able to foster community attachment. Besides, Prezza et al. (2001) found in their study that moving away from the big city to a town smaller but closer to nature increased movers' sense of community, which is consistent with Hummon's (1992) finding that there was an increase in community satisfaction after moving to more rural neighborhoods. De Sousa (2003) also discovered that the project 'turning brownfields green' had the ability to enhance the sense of community, which in a way supports the effects of green facilities on sense of community. In short, green facilities are able to facilitate a sense of community through increasing residents' identity with a place and emotional attachment to a neighborhood, strengthening residents' bonds with others and fostering the accessibility to local exploration.

On the other side, evidence suggests that there is an association between sense of community and mental health (De Silva et al., 2005; Ellaway et al., 2001; Dumont, 2002; Dumont, 2002). In their study, Ellaway et al. (2001) did an analysis in four socially contrasting neighborhoods in Glasgow testing the association between perceptions of neighborhood environment and self-assessed health, mental health, and recent symptoms. They collected data from 592 adults from these four neighborhoods and found that after adjusting for individual characteristics, there was a significant positive correlation between psychological sense of community and mental health status and with the malaise-type symptoms. In addition, in 2002, Dumont examined the links between neighborhood conditions and psychological distress of 397 adult African-American and Latino women from 317 census block groups. The result revealed a significant association that a higher sense of community was related with the lower level of mental illness (Dumont, 2002). These studies offered evidence that sense of community is conducive to mental health. Accordingly, green facilities in the neighborhood are able to impact mental health through enhancing the sense of community which has been shown to be beneficial for mental health.

However, mediating mechanisms social ties and sense of community are not entirely disconnected, individuals' social ties can exert an influence on their sense of community. Social interaction with other people and social support are said to be sources of community attachment, helping develop a sense of belonging and a feeling of home (Thoits, 1985; Cutrona and Russell, 1990; Barrera, 2000; Thoits, 2011). A sense of belonging and a feeling of home indicate the acceptance and inclusion by community members,

while community members do not automatically grant this acceptance and inclusion, they need to perceive themselves as part of a community, belonging to the community network and mutual obligation, and be willing to share social activities with others. Accordingly, social contacts and social support expressed between community members can benefit residents' community attachment, help strengthening the bonds with others and constructing community identity, thus contributing to residents' sense of community in general. A greater level of social ties is usually accompanied by a better sense of community (Barrera, 2000). Therefore, the relationship between social ties and sense of community should be taken into consideration.

In summary, as discussed above in this section, four mechanisms: direct exposure and other three intermediate mechanisms: physical activity, social ties and sense of community might play a role in helping explain the association between green facilities and mental health, in which sense of community is influenced by social ties as well.

However, the intermediate mechanisms could also be interfered by some confounding factors such as gender and current financial status other than green facilities. For example, descriptive epidemiological studies of physical activity among youth population have consistently reported that males tend to be more active than females (e.g., Sallis, 1993; Trost et al., 2002) while there are also studies about university students providing contradictory findings, showing that male students are less interested in health enhancing activities and tend to be more physically inactive than female students (e.g., Von Bothmer and Fridlund, 2005). Not only gender, but it is also possible that socioeconomic status can affect university students' social ties and sense of community in the neighborhood as students who are in a financial struggle might have to live in a non-ideal neighborhood, resulting in a lower satisfactory towards the neighborhood, thus contributing to a lower level of sense of community. These confounding factors can have an influence on the mediating process behind the association between green facilities and mental health thus shall not be neglected.

2.5. Development of conceptual model and final research questions

Following these theoretical developments, the conceptual framework is illustrated as Figure. 1. Both the proportion of green facilities in students' living neighborhood and university students' use-frequency of green facilities in their neighbourhoods are examined respectively. They may directly exert an influence on university students' mental health through exposure to green settings, while it is assumed that the causation mechanisms can also take other possible forms: through three mediating features – physical activity, social ties, and sense of community in which social ties are considered to have an influence on sense of community. Besides, the demographic and socio-economic status, housing condition and lifestyle correlates of the individual level are considered to impact students' mental health (e.g., Byles et al., 2012; Feng et al., 2013). Gender and socio-economic status are regarded as related to three mediating mechanisms, thereby incorporated in the framework.

Exposure to green

Intermediate mechanisms

Physical activity

Social ties

Sense of community

Green facilities
➤ The proportions of green facilities
➤ The use of green facilities

Gender, socioeconomic status

Control variables: demographic and socio-economic status, housing condition, lifestyle correlates

University students' mental health
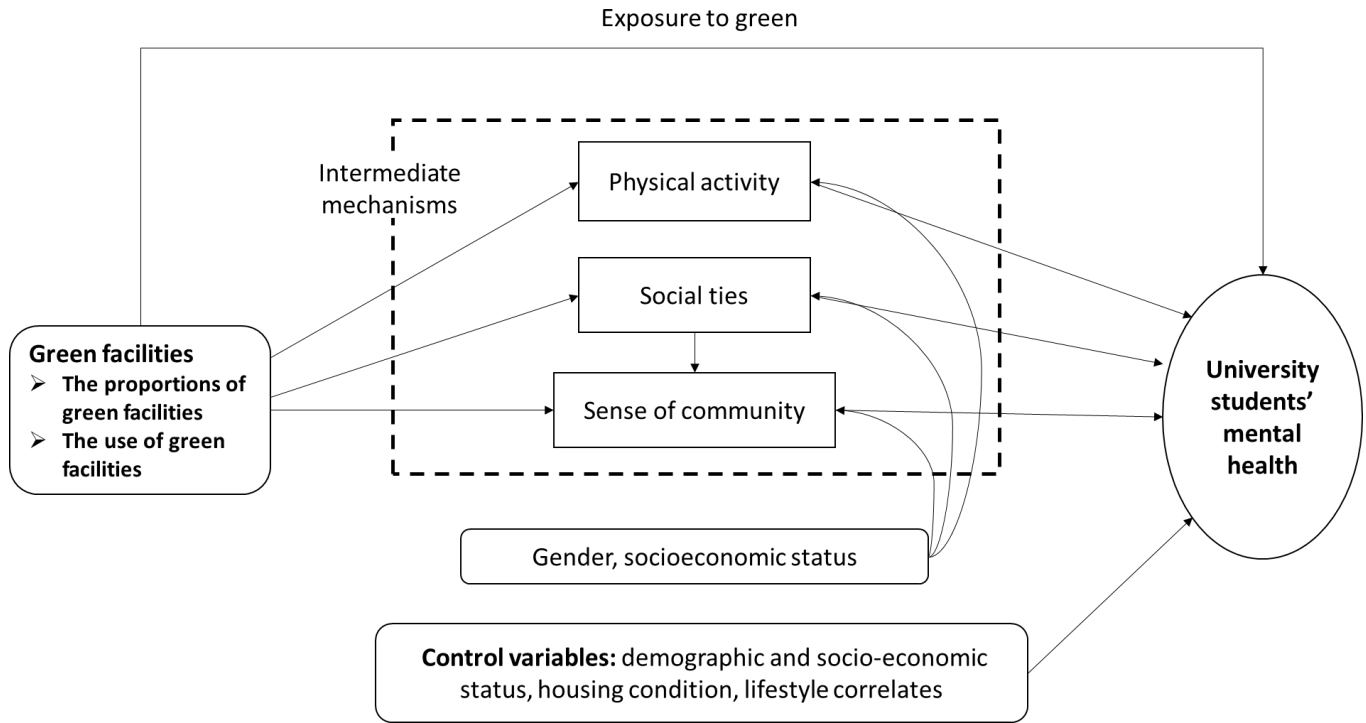
Fig. 1 Conceptual model

This study will provide answers to the following questions:

1. To what extent is the proportion of green facilities in university students' living neighborhood associated with their mental health?

2. To what extent is university students' use of green facilities in their neighbourhoods associated with their mental health?

3. To what extent are the two associations mediated through the physical activity, social ties, and sense of community respectively?

4. To what extent does the association between green facilities and mental health and the mediation effects differ between different socio-demographic groups?

3. Research design

3.1. Research methodology

In this study, quantitative methods were used to investigate the relationship as well as the underlying mechanisms between green facilities and university students' mental health. The data used was a combination of two datasets deriving from a survey among university students in Utrecht as well as two land-use databases of the Netherlands. The data concerning university students' mental health status, their use-frequency of green facilities in their living neighborhoods, their levels of physical activity, social ties, sense of community, and their personal characteristics were originated from the survey while the data about the proportion of green facilities in their living neighborhoods was objectively measured using two land use databases: LGN7 and BBG2012. It is worth noting that, in this study, the data of direct exposure of green facilities on mental health was not directly collected and analyzed due to the practical reasons and time limitation. The effect of direct exposure in greenery was identified in the analysis as the direct linkage between green facilities and mental health.

3.1.1. Survey

3.1.1.1 study area and population

The study area is the city of Utrecht, Netherlands. Utrecht was chosen in this research for several reasons. Firstly, in Utrecht, there have been several universities such as Utrecht University, University of Applied Science Utrecht, resulting in an accumulation of large numbers of students in this city. Second, universities in Utrecht don't provide dormitories for students, students have to find their own houses or apartments. Lots of students are living outside the campus. Students don't aggregate in certain areas but tend to spread across the city or even across the Netherlands due to convenient transport. The variety of students' living neighborhoods choices make Utrecht suitable for this study. Study population for this research is the university students in Utrecht, including not only students in Utrecht University, Hogeschool Utrecht and some other schools in Utrecht, but also university students living in Utrecht but studying in schools located in other cities. Students who are attending a course or in an exchange program were comprised as well.

3.1.1.2 survey design

To acquire the data asked for in this research, a survey was held among the research subjects asking about the following concepts:

Mental health

To measure mental health, SCL-10 (Strand et al., 2003) was used in this study. SCL-10 is a ten-item version of the SCL-25 which includes 25 items two symptom dimensions (depression and anxiety) as a shortened version of the SCL-90-R (8) with originally 90 items on nine symptom dimensions (Somatization, Obsessive Compulsive, Interpersonal Sensitivity, Depression, Anxiety, Hostility, Phobic Anxiety, Paranoid Ideation, and Psychoticism) (Derogatis et al., 1976). It has been proved that the SCL-25 has a satisfactory validity

and reliability to measure psychological distress (Glass et al., 1978), and research shows that the shorted versions of SCL-25 performs approximately as well as the full version (Strand et al., 2003). Therefore, it is advisable to replace SCL-25 with shorted versions when there is a lack of space in a comprehensive questionnaire. SCL-10 includes 10 items such as faintness, feeling fearful and tensed, hopeless and self-blaming specifically asking for symptoms of depression and anxiety, indicating participants' mental condition in the past seven days and four-point scales ranging from 'not at all' to 'extremely'. The average value of these items was computed. Because the SCL measures the extent to which people experience different symptoms of mental distress, a higher score represents greater mental illness and poorer mental health. The cut-off value is 1.85 therefore mentally healthy people will score under 1.85 while higher scores indicates mental problems (Strand et al., 2003).

The use-frequency of green facilities

The use-frequency of green facilities in the neighborhood was measured by asking respondents how many times a week they used three different types of green facilities in their neighborhoods (urban parks, forest or nature areas, green sports facilities) respectively and how many hours per time they spent. The use-frequency of all green facilities in the neighborhood, that is, the total number of hours a week spent in green facilities in the neighborhood was calculated by multiplying the number of times per week spent on all types of green facilities with the number of hours per time spent on all types of green facilities.

Physical activity

Level of physical activity was assessed as the total active hours of people performing different physical activities on an average week. For this study, only commuting activities and leisure-time physical activities were taken into account as the occupational and household activity are not expected to be influenced by green facilities in the neighborhood. Therefore, the overall numbers of hours of walking, running, cycling and sport activities during both leisure time and of commuting purpose were asked for.

Social ties

This research used two measures: social contacts and social support, for university students' social ties.

Social contacts—includes four indicators. Respondents were asked questions about how often they had contact with their friends, family members and neighbors inside and outside neighborhood green facilities, how many friends they had regular contact with and how often they greeted encounters in the neighborhood.

Social support—contains two indicators. To tap to what extent university students experience social support, they were asked to indicate on a five-point scales from 'not at all' to 'extremely' with to what extent they felt socially supported by their direct physical and social environment, and to what extent they felt about people around their living environment concerned with helping and supporting each other.

Sense of community

Sense of community was measured by asking the respondents to what extent they agreed with the four statements with regard to four domains of sense of community—their feelings of attachment, bonds with other residents, the identity of community, and pedestrianism. An additional statement directly regarding people's feeling of sense of community in the neighborhood was also included. All five statements required a response on five-point scales: 'strongly disagree' (1), 'disagree' (2), 'neutral' (3), 'agree' (4), 'strongly agree' (5). The average extent of agreement with the four statements about four domains of sense of community was computed.

Personal characteristics

As discussed above that university students' mental health and intermediate mechanisms can differ according to people's background characteristics, therefore, several personal characteristics were taken into consideration.

The demographic characteristics—included age (years), gender, nationality which was divided as three groups (Dutch, other Europeans, non-European).

Socio-economic status—measured by students' education institution, parental education level (including five categories: elementary school or less, secondary school, higher vocational education, academic education, and unknown) and current financial status (divided into three categories: 'It's a financial struggle', 'It's tight but I'm doing fine', and 'Finances aren't really a problem'). Category 'unknown' for level of parental education was included to avoid excessive drop-out of respondents.

Housing—measured by housing situation (a half-open question with five given choices provided and one blank to specify if none of these five situations fits) and living duration (years). The five given choices include: (1) live in a student house with other students; (2) Live in an individually rented room in an apartment or a house; (3) live with a partner; (4) live individually in a studio or an apartment; and (5) live with parents.

Life correlates—referred to smoking and drinking status. Respondents were asked about the numbers of cigarettes and drinks they consume on an average week.

The appendix contains the questionnaire used in this study. It takes about 15-20 mins to complete as monitored during the pilot test where a few of my friends were invited to take the test and comment on the mechanisms. To guide participants through the questionnaire, questions were structured in seven sections: (1) Basic information, including 15 questions about the personal characteristics of participants. Particularly, the six-character postal code of participants' home address was included. (2) Mental health, using SCL-10. (3) Green facilities in participants' neighborhoods. 5 questions about the use frequency of green facilities, contacts with friends or encounters inside green facilities were mentioned, while the other 2 questions asking the most often visited parks inside as well as outside participants' neighborhood were used to help identify the areas of neighborhood. (4) Friends and social support, involving 6 questions about contacts with friends and neighbors as well as social support. (5) Physical activities. Questions on both activities in general and activities performed in green facilities were asked. (6) Sense of community.

(7) Suggestions from the participants, about the ways that they thought this questionnaire could be improved.

The questionnaire was checked for completeness by the researcher after the participants had finished it. And if applicable, missing answers would be pointed out and the researcher would consult the participants if they would like to add them in. The privacy of the participating persons is guaranteed and the data acquired from the survey is not shared with others.

3.1.1.3 participants recruitment

Questionnaires were handed to the participants face-to-face by the author in October 2016. Participants were recruited in several different ways. First, questionnaires were sent away to students in Utrecht University libraries in both city center and de Uithof as they are important places with a concentration of students from different universities who are studying or meeting friends there. The second way was to go to classrooms in the University before and after the lectures, asking students if they were willing to fill in the questionnaires. The information about course schedules was attained from my friends studying in different faculties in Utrecht University and University of Applied Science Utrecht. The cafeteria in de Uithof and some student lounges have also been visited. In addition, people in the campus de Uithof and UCU were randomly asked if they were university students and whether they were willing to fill in the questionnaire. In total 400 questionnaires were sent to students. Eventually 385 questionnaires were returned leading to a response rate of 96.25%. After correcting for missing values 342 cases were used for statistical analysis.

3.1.2. Geographical data

The proportion of green facilities in the neighborhood was derived from two land-use datasets (LGN7 and BBG). The geographic scale of neighborhood around university students' home is defined as a radius of 300m. 300 meters was chosen as it can reflect the impact of green facilities in an intermediate neighborhood. Also, it is recommended by Natural England that all residents should be able to access green facilities within 300m around their homes (Coombes et al., 2010). Accordingly, 300m distance buffer from the six-character postal code of the home address, representing the neighborhood area in this study, was selected for measuring the proportion of green facilities in the neighborhood in the Netherlands. Geographical information system (GIS) technique was used in calculating the proportion of green facilities in respondents' neighborhood.

LGN7 and BBG2012 are two important databases that deal with land cover at national scale in the Netherlands. These two databases both cover the entire country but possess different properties and were produced based on different specifications. The Dutch land use database LGN7 is short for "Landelijk Grondgebruiksbestand Nederland". It is a grid database of 25m by 25m reflecting the land cover with 39 classes involving urban areas, forest types, agricultural crop types, water, nature and some other ecological classes (Hazeu et al, 2014). The LGN7 database is the newest database in the series, it

reproduces the usage of land in the Netherlands in 2012. Another database is Land Use database "Bestand BodemGebruik 2012", abbreviated as BBG2012. It includes digital geometry of land use in the Netherlands, reflecting land cover for 8 big classes. The examples of usage of land are traffic area, agricultural area, build-up areas, recreational grounds, inland and open water (CBS, 2012). This database plays a leading role in interpreting aerial photographs and BBG2012 was the most recent version in the BBG land use data series at that time when geodata were processed.

To begin with, the LGN7 database (Hazeu et al, 2014) was converted from raster data to vector data in order to calculate the areas of green facilities. As the LGN7 database contains only information on the dominant land use in 25 by 25 m grid cells, small-scale green spaces such as street trees and green roadsides are not represented in the database, therefore they were not included in the measures of green facilities. According to the classifications of LGN7 database, I categorized green facilities into low (such as grass, bushes) and tall vegetation (such as trees). As for BBG2012 database (CBS, 2012), urban parks, green sports facilities, and forest and nature areas were categorized. Different types of green facilities of these two databases were distracted as shown in Figure 3.1, 3.2.

Figure 3.1. Map of Utrecht indicating distribution of green facilities using LGN7
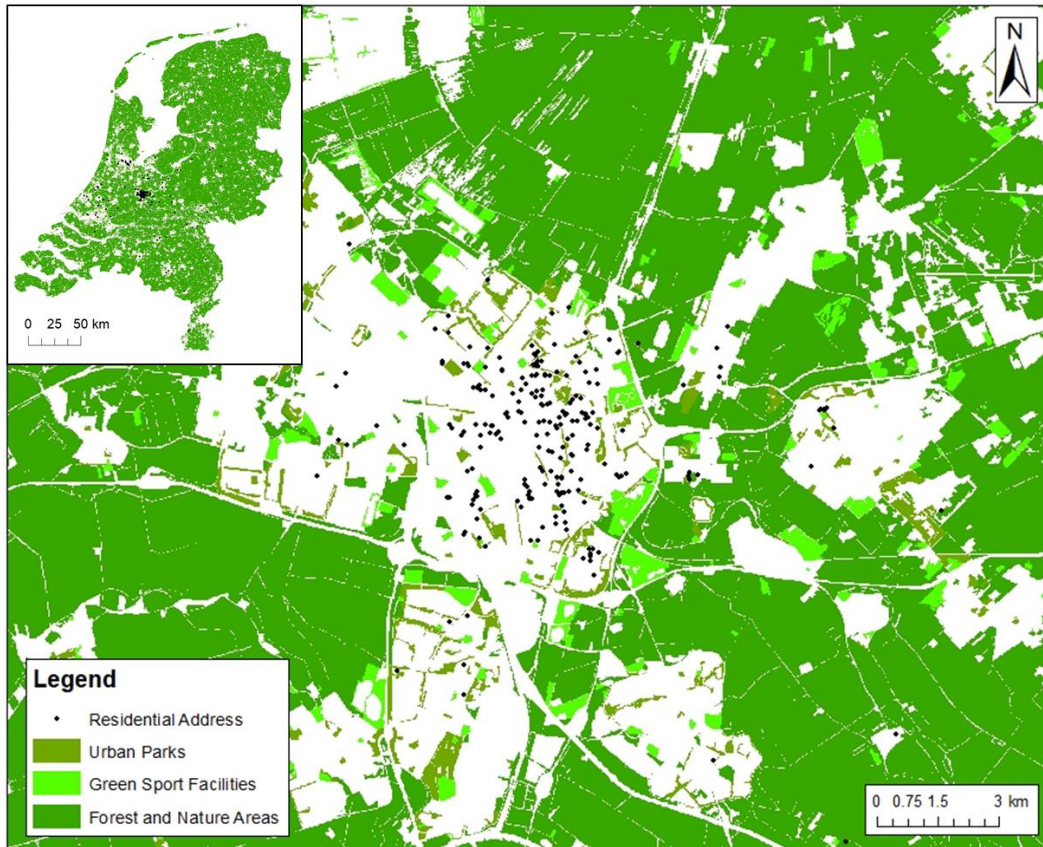
Figure 3.2. Map of Utrecht indicating distribution of green facilities using BBG2012

The six-character postal code of participants' home address were acquired from the survey (on average about 15-20 households have the same six-character postal code). Based on the X and Y coordinates of these postal codes, the participants' home address data was matched with these two land-use databases (see Figure 3.1, 3.2). The 300m Euclidean distance buffer was created around the participants' home address and I made an intersection between the 300m Euclidean buffer and the two extracted green facilities datasets (see Figure 3.3, 3.4). Accordingly, the square meters of green facilities in the 300m buffer and the proportion of green facilities were then computed using the attribute data. Separate calculations were run for the proportions of different types of green facilities from two different databases in the intersection areas, yielding 2 measures of green facilities in the neighborhood: (1) Proportion of total green facilities of LGN7 within 300m; and (2) Proportion of total green facilities of BBG2012 within 300m.
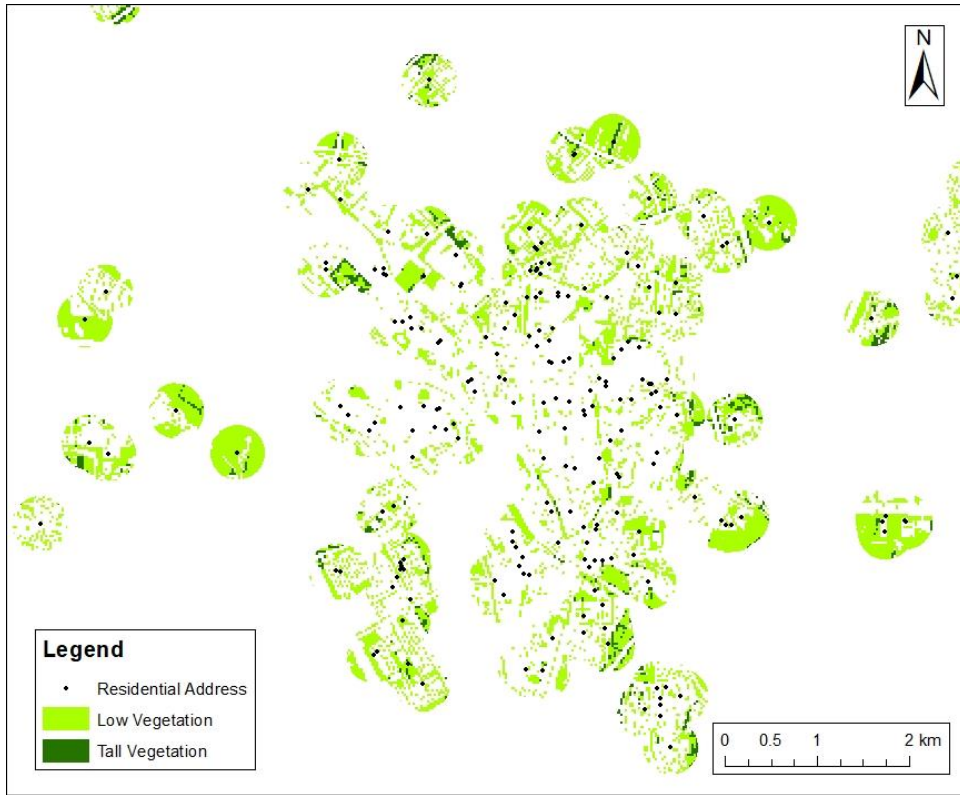
Figure 3.3 Map of green facilities in 300m neighborhood from LGN7
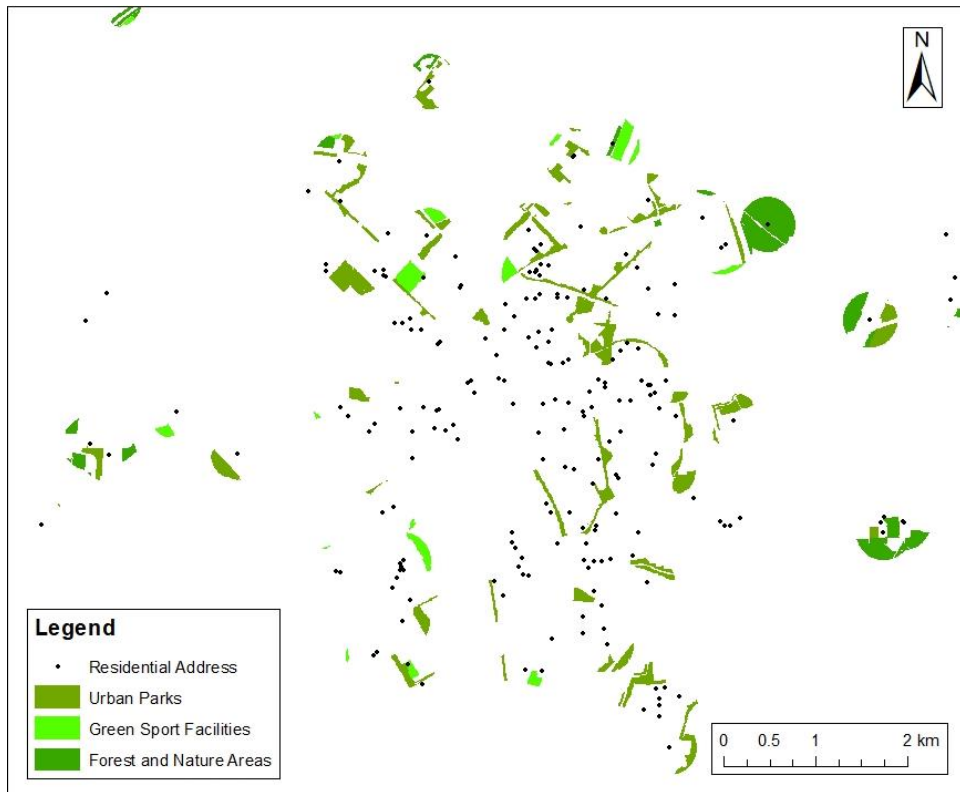
Figure 3.4 Map of green facilities in 300m neighborhood from BBG2012

24

3.2. Structural equation modeling (SEM)

This study considered the establishment of structural equation model (SEM) to study the relationship between mental health of university students (endogenous latent variable) and green facilities in the neighborhood (including both the objective measured proportion of green facilities and individuals' subjective use of green facilities in the neighborhood) as well as to quantify this relationship. This research involves a direct association and the indirect associations (mediating through physical activity, social ties, and sense of community) of green facilities and mental health. There is a potential association between social ties and sense of community. Also, the intermediate mechanisms might also be interfered by other confounding factors such as gender and current financial status. Compared with Baron and Kenny (1986) regressions, SEM models to study mediation paths allow for many extensions and perform better in mediation analysis (Iacobucci et al., 2007). Therefore, structural equation model was chosen to be applied to this research.

Structural equation modeling (SEM) is a statistical methodology based on statistical analysis techniques, which can be used to deal with the exploration and analysis of complex multivariate research data and to analyze structural relationships. It is important that SEM can simultaneously conduct the estimation of potential variables and the parameter estimation of the forecasting model of complex independent variables/dependent variables, and therefore be classified as a part of multivariate statistics.

In SEM, for a studied problem, the phenomenon that cannot be directly measured is recorded as latent variable or hidden variable; the directly measurable variable is called the manifest variable or the apparent variable. The advantage of the structural equation model is the introduction of latent variables (variables that cannot be directly observed). That is, it considers the problem in the following way:

X indicator --- exogenous latent variable --- endogenous latent variable --- Y indicator

In which X indicator is an exogenous manifest variable while Y indicator an endogenous manifest variable. Thus, the study of the effect of exogenous latent variables on endogenous latent variables is essentially an indirect study of the effect of X-index on Y-index. However, the structural equation divides the indices controlled by the same latent variable into a class, indicating that this type of indices is affected by that latent variable, making the analysis of the problem more systematic.

SEM is an extension of the general linear model, which is mainly used to study the relationship between the non-direct observed variable (latent variable) and the observed variable as well as the relationships between the latent variables. Generally, the structural equation model is a complex composite statistical hypothesis, which includes two main parts: measurement model and path model. The relationship between the observed and the latent variables is obtained from the measurement model. The path model determines the relationship of dependency, usually accepted to be in some sense causality, between the latent variables. We reserve the term structural model here for the composite SEM, the combined measurement and path models. This avoids the ambiguity that arises when the path model component is also labeled "the" structural model.

The measurement model, also known as the confirmatory factor analysis model, mainly represents the relationship between the observed variable and the latent variable. The metric model is usually composed of two equations, which specify the connections between the endogenous potential variable η and the endogenous vector Y (i.e., the observed variable), and between the exogenous potential variable ξ and the exogenous vector X. The model form is:

$$\begin{cases} X_m = A_x\xi + \delta \\ Y_n = A_y\eta + \varepsilon \end{cases}$$

Here, $X = (x_1, x_2, \ldots \ldots, x_m)^T$ is a column vector consisting of m exogenous indices; $\xi = (\xi_1, \xi_2, \ldots \ldots, \xi_u)^T$ is a column vector consisting of u exogenous latent variables; A_X is a matrix of $m \times u$ dimensions, called the factor loading matrix of X on ξ. It describes the relationship between the exogenous index and the exogenous latent variable; $\delta = (\delta_1, \delta_2, \ldots \ldots, \delta_m)^T$ is an error term column vector of m dimensions. $Y = (y_1, y_2, \ldots \ldots, y_n)^T$ is a column vector composed of n endogenous indices; $\eta = (\eta_1, \eta_2, \ldots \ldots, \eta_v)^T$ is a column vector consisting of v endogenous variables; A_Y is a matrix of $n \times v$ dimensions, called the factor loading matrix of Y on η. It describes the relationship between endogenous and endogenous latent variables; $\varepsilon = (\varepsilon_1, \varepsilon_2, \ldots \ldots, \varepsilon_n)^T$ is a n-dimensional error term column vector.

The path model, also known as latent variable causal relationship model, mainly represents the relationship between latent variables. It prescribes the causal relationship between the potential exogenous variables and potential endogenous variables assumed in the studied system. The model form is:

$$\eta = B\eta + \Gamma\xi + \gamma$$

Here, η and ξ have the same meaning as above; B is a $v \times v$-dimensional matrix that describes the relationship between endogenous latent variables; Γ is a matrix of $v \times u$ dimensions, a loading of η on ξ, which describes the effect of exogenous latent variables on endogenous latent variables; $\gamma = (\gamma_1, \gamma_2, \ldots \ldots, \gamma_v)^T$ is a v-dimensional structural model residual term column vector, which reflects the part of the model that cannot explain η.

There are five basic steps in the process of the structural equation modeling analysis, namely model specification, model identification, model estimation, model testing and model modification (Schumacker and Lomax, 2004)

3.3. Statistical analysis

3.3.1 Descriptives and bivariates

Table 3.1 reports the descriptive statistics for the research objects including the proportion of green facilities in their neighborhoods from two different databases (LGN7 and BBG2012). The sample consists of 60.8% females and 39.2% males. Age categories are presented between 17 and 35 years old, with the largest category (55%) being 21 years old. The sample contains mostly Dutch students. But still some students from other European countries or non-EU countries are included. In terms of housing situation,

over half of the sample (56.7%) live in a student house with other students, while 16.7% of the sample live with their parents and 13.7% living in an individually rented room in an apartment or a house.

In light of university students' mental health measured by SCL-10, an item analysis has been conducted to provide a reliability coefficient for this ten-items scale. The Cronbach's α was computed and the value (Cronbach's α = 0.809 > 0.7) indicated that SCL-10 scale used in this study to measure mental health was reliable. 36.8% of the sample scored 1.85 or higher on SCL-10, which indicates having symptoms of psychological distress (Strand et al., 2003). The majority of the participants (68.4%) uses green facilities in their neighborhood only for 2.5 hours or less per week, while there are still 2.0% of the sample using more than 15 hours per week. The proportion of green facilities in the neighborhood tends to be different from two databases probably due to the different means of categorizing. For database LGN7, 64.0% of the participants have a proportion of 30% or less of green facilities in their neighborhoods, 32.5% have a proportion of green facilities between 30% and 60%. However, in database BBG2012, only 4.7% have a proportion of green facilities in their neighborhood between 30% and 60%, 93.0% participants only have 30% of green areas in their neighborhoods.

Table 3.1: Characteristics of the study sample (N=342).

	%(N)	Mean (Std.Dev.)
Gender		
Female	60.8	
Male	39.2	
Age (years old)		22.17(2.83)
17-22	57.0	
23-28	40.7	
29-35	2.3	
Nationality		
Dutch	79.8	
Other European countries	12.0	
Others	8.2	
Housing situation		
Living individually in a studio or an apartment	5.0	
Living in a student house with other students	56.7	
Living in an individually rented room in an apartment or a house	13.7	
Living with a partner	5.3	
Live with parents	16.7	
others	2.6	
Living duration (years)		
0-1	44.4	
1-2	16.7	
2-3	12.0	
3-4	7.3	
4-5	2.6	
5-15	5.6	
15-25	11.4	
Current financial status		
It's a financial struggle	8.8	
It's tight but I'm doing fine	56.4	
Finances aren't really a problem	34.8	
Smoking status (cigarettes)		
none	74.0	
1-7 per week	13.2	
8 or more per week	12.8	
Drinking status (drinks)		
none	14.9	

1-4 per week	28.4	
5-8 per week	20.2	
9-12 per week	14.9	
13-16 per week	8.2	
17-20 per week	6.7	
21 or more per week	6.7	
Mental health (SCL-10)		1.73 (0.47)
<1.85	63.2	
>=1.85	36.8	
Use-frequency of green facilities in the neighborhood (hours per week)		2.44(3.46)
0-2.5	68.4	
2.5-5	19.3	
5-15	10.3	
15-26	2.0	
Proportion of green facilities in 300m buffer (LGN7 database)		0.26(0.16)
0-0.3	64.0	
0.3-0.6	32.5	
0.6-0.9	3.5	
Proportion of green facilities in 300m buffer (BBG2012 database)		0.11(0.15)
0-0.3	93.0	
0.3-0.6	4.7	
0.6-1	2.3	

Before proceeding to modelling, the categorical variables in this study were changed into a series of dummy variables. Specially, categorical variable 'current financial status' was changed to a dummy variable 'current financial status': 'it's a financial struggle=1' and 'it's not a financial struggle=0'. Same was 'nationality', the changed dummy variable 'nationality' was categorized as 'Dutch=1' and 'non-Dutch=0'.

Bivariate analyses were conducted among university students' mental health, their physical activity levels, social ties, sense of community, and green facilities in their neighborhoods. Table 3.2 presents the bivariate outcomes between students' mental health and greenery. Although as expected the Pearson's r value is negative, the insignificance of Pearson's r value shows that there is no relationship between university students' use-frequency of green facilities in the neighborhood and their mental health as well as between the proportion of green facilities in their living neighborhoods and mental health, which could be a result of the interference of other control variables. Bivariate tests also reveal that students' physical activity, contact frequencies with neighbors, the numbers of university students' friends with regular contact, and a general sense of community are positively correlated with their use-frequency of green

facilities in the neighborhood but negatively correlated with the proportion of green facilities in the neighborhood.

The correlation between the independent variable use-frequency of green facilities in the neighborhood and the control variables has been examined. It appears that the use-frequency of green facilities in their neighborhoods is correlated with the gender and current financial status of university students thereby incorporated in the model construction, while there is no correlation shown between gender and current financial status. Other control variables including the age, nationality, education institution, housing situation, living duration, mother educational level, father educational level, smoking status, and drinking status of university students show no correlation with the use-frequency of green facilities in their neighborhoods.

Table 3.2: Pearson Correlation between mental health and greenery

		Mental health (SCL-10)
Use-frequency of green facilities in the neighborhood	Pearson Correlation	-.030
	Sig. (2-tailed)	.575
	N	342
Proportion of green facilities in the neighborhood (LGN7)	Pearson Correlation	-.022
	Sig. (2-tailed)	.692
	N	342
Proportion of green facilities in the neighborhood (BBG2012)	Pearson Correlation	-.006
	Sig. (2-tailed)	.911
	N	342

3.3.2 Model design

According to previous literature, this study put forward a conceptual model, based on which the latent variables were identified and model structure was constructed. Using processed survey data from questionnaires and green facilities data calculated and extracted by GIS techniques from LGN7 and BBG2012 land-use databases, I tested two structural equation models in this study, accessed their fitness, modified, and interpreted them.

This study built two structural equation models: Model 1 and Model 2. In Model 1, the use-frequency of green facilities in the neighborhood was used as the independent variable, while for Model 2 the independent variable I aimed to examine was the proportion of green facilities in the neighborhood. The dependent variable for both Model 1 and 2 was the mental health status of university students. And the intermediate variables comprised students' physical activity, social ties, and sense of community. Variables including age, gender, nationality, education institution, housing situation, living duration, mother's educational level, father's educational level, current financial status, smoking status and drinking status might have an influence on university students' mental health, hence, these variables were controlled in both two models. The relationships between the mediating variables (physical activity, social ties, and sense of community) and gender and current financial status were taken into account in two models as well.

Model 1 and Model 2 both contained two latent variables: social ties and sense of community, which were endogenous variables. Social ties contained six indicators and sense of community contained two indicators. The other variables were all manifest observed variables. Figure 3.5 and 3.6 respectively show the designed structural paths of model 1 and model 2. The causal pathways I aimed to test in this study are displayed as arrows. Compared with Model 2, Model 1 included the pathways from 'gender' and 'current financial status' to 'use-frequency of green facilities'. The original indicators for two latent variables are presented in Table 3.2.
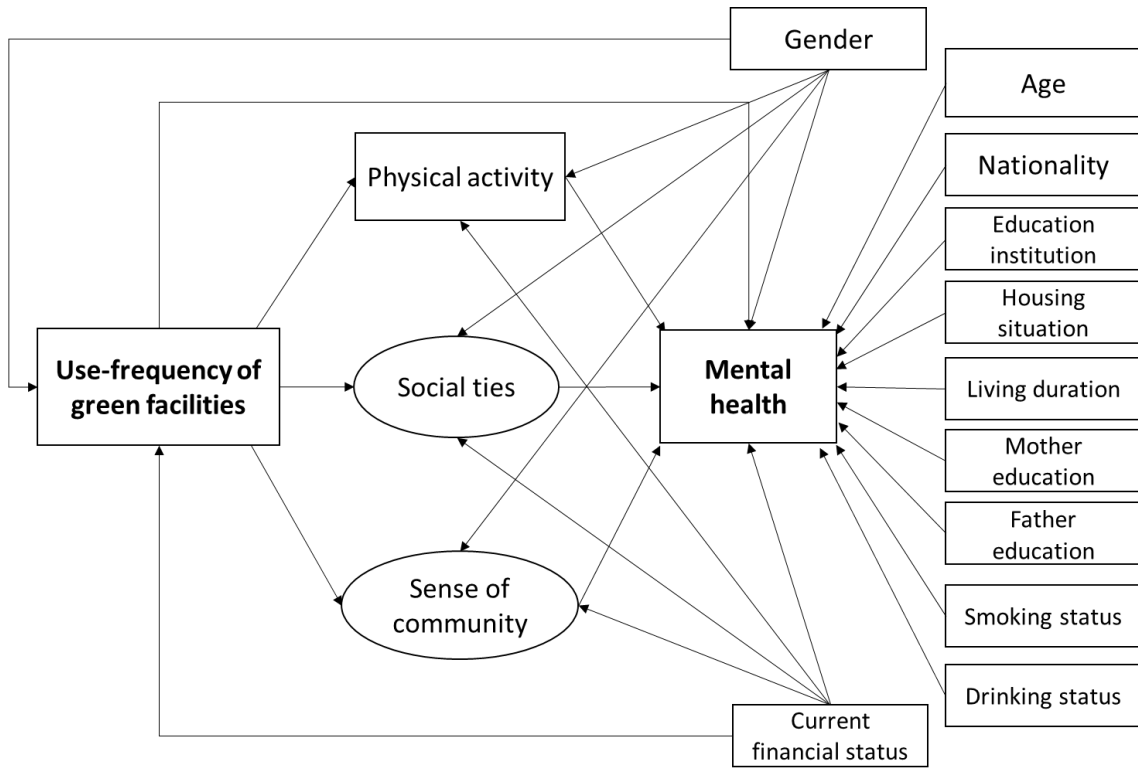
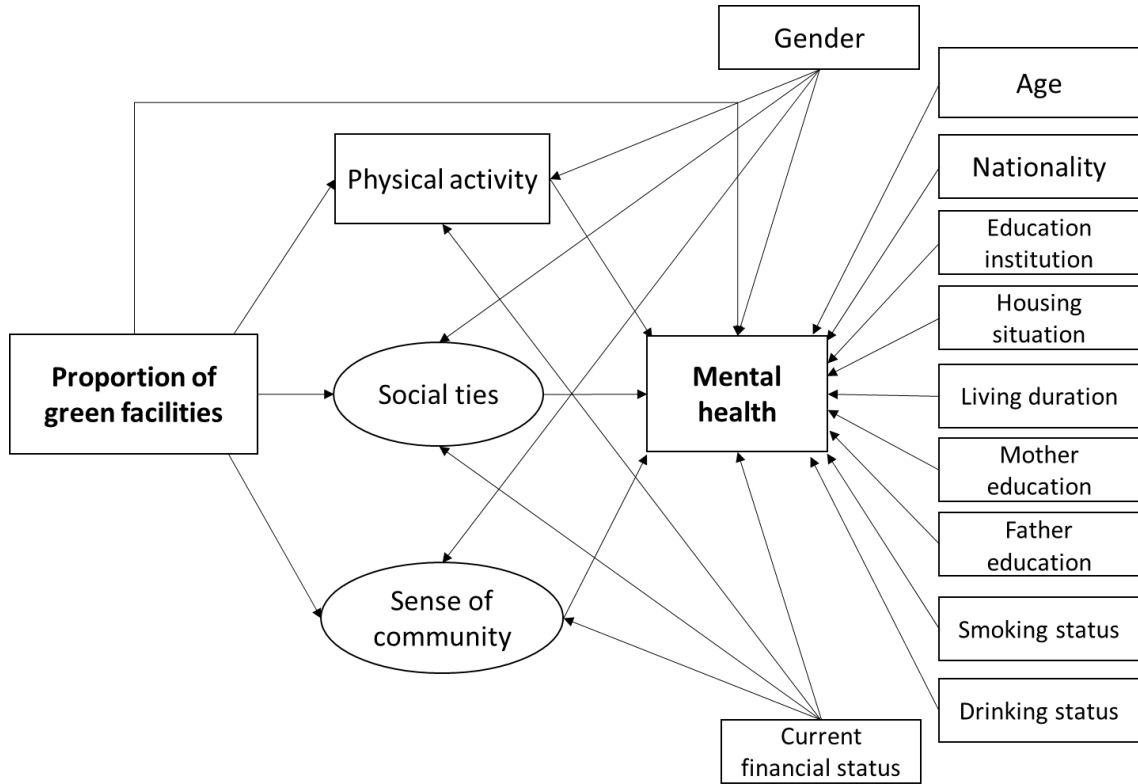**Figure 3.5 Designed structural paths of Model 1**

Figure 3.6 Designed structural paths of Model 2

Table 3.2: Latent variables and indicators

Latent variables	Indicators
Social ties	➢ The frequency that university students greet encounters in their neighborhood (a1) ➢ The numbers of university students' friends with regular contact (a2) ➢ The frequency that university students meet with their friends (a3) ➢ The frequency that university students have contact with their neighbors (a4) ➢ The extent that university students feel socially supported by their direct physical and social environment (a5) ➢ The extent that people in university students' neighborhoods concerned with helping and supporting each other (a6)
Sense of community	➢ The extent of agreement that living in their neighborhood gives university students a sense of community (a7) ➢ The computed average extent of agreement that university students feel at home, feel having bonds with people in their neighborhoods, feel a sense of connection with their neighborhood and feel walking around the neighborhood pleasant and convenient (a8)

3.3.3 Confirmatory factor analysis

Before starting the analysis of structural model, the measurement model underlying a full structural equation model usually needs to be tested first. Only if a good fitness of the measurement model is found can the test of structural model be continued. To validate the measurement model of latent constructs, the Confirmatory Factor Analysis (CFA) provides a comprehensive means to assess the unidimensionality, validity and reliability of a latent construct. It is worth noting that the assessment of unidimensionality should be made before assessing the validity and reliability of a latent construct. CFA is supposed to be performed for all latent variables involved in the study and can be run separately for every measurement model or, more efficiently and highly recommended, for the pooled measurement model at once (called Pooled-CFA).

In this study, the Pooled-CFA procedure was employed. The latent variables: social ties and sense of community as well as their indicators were added in the pooled measurement model at a time. The pooled measurement model was executed for the first time and the CFA results showing fitness indices and factor loadings for every item together with its R^2 revealed that certain fitness indices do not achieve the required level (such as P-value for Chi-square was much lower than 0.05). The factor loading for item a1,

a2, a3, and a4 (from latent variable 'social ties') were below 0.5. These four 'problematic items' which didn't fulfill the unidimensionality requirement of a measurement model had contributed to the poor fitness of the measurement model thereby needed to be deleted from the model.

After deleting the four items (a1, a2, a3, and a4) the new pooled measurement model was run again and the fitness indices for the model are as shown in the following table (Table 3.3). The model fitness achieved the required level and the unidimensionality requirement was also fulfilled as the factor loadings of the items left were positive and above 0.5. In the new pooled measurement model, the latent variable 'social ties' only had two 'useful' indicators concerning the social support level left, the other four indicators about social contacts were dropped due to low factor loadings.

Table 3.3: The fitness indexes for new pooled measurement model

Name of category	Name of index	Index value	Comments
1. Absolute fit	Chi-Square	P-value=0.181	Required level achieved
	RMSEA	0.048	Required level achieved
	GFI	0.997	Required level achieved
2. Incremental fit	CFI	0.997	Required level achieved
	AGFI	0.974	Required level achieved
3. Parsimonious fit	Chisq/df	1.788	Required level achieved

Before modeling the structural model, it is necessary to assess for unidimensionality, validity and reliability for measurement models. The unidimensionality requirement was achieved through the item-deleting procedure when adjusting model to a good fitness. Apart from the fitness requirements of the measurement models for latent variables, the validity and reliability of measurement models are usually evaluated using three extra indexes: Cronbach's Alpha, CR (Composit Reliability), and AVE (Average Variance Extracted). The validity and reliability requirements are achieved when the value of Cronbach's Alpha exceeds 0.7, an AVE ≥ 0.5 and the value of CR ≥ 0.6. Table 3.4 shows the CFA report and the Cronbach's Alpha, CR, and AVE for the latent variables in the study. We can see that the Cronbach's Alpha for latent variable 'social ties' is a little bit lower than 0.7 (0.658). the relatively low Cronbach's Alpha value might be because there are only two items or there is a lack of homogeneity of variances among items. But because all the fit indices of measurement model in CFA were above the cut-off and the CFA report showed a good validity and reliability of AVE and CR, it is acceptable to still keep latent variable 'social ties' and its two indicators (a5 and a6) in the model.

Table 3.4: CFA report and Cronbach's Alpha for each latent variable in the study

Latent variables	Indicators	Factor loading	Cronbach's Alpha	AVE	CR
Social ties	a1	deleted	0.658	**0.524**	**0.681**
	a2	deleted			
	a3	deleted			
	a4	deleted			
	a5	0.589			
	a6	0.837			
Sense of community	a7	0.784	**0.763**	**0.643**	**0.783**
	a8	0.819			

The final step took before proceeding to modeling the structural model was the assessment of the normality for the data in the final pooled measurement model. According to the output of CFA, the absolute value of skewness, the Critical Region (CR) for the skewness, and the Critical Region (CR) for the kurtosis (the multivariate kurtosis statistic) were both lower than their corresponding cut-off values, indicating that the data in the final measurement models was normally distributed.

4. Empirical results

4.1. Use-frequency of green facilities and mental health

According to the model design, structural equation model: Model 1, which aims to test the association between university students' use-frequency of green facilities in their neighborhoods and their mental health, was estimated and "Maximum Likelihood Estimates" method was conducted in AMOS. As the original literature derived model "Model 1" didn't provide a good fit (χ^2/df = 5.701, RMSEA = 0.117, GFI = 0.827, AGFI= 0.757, NFI = 0.361, CFI =0.387, see Table 4.1), based on the consideration of the fitness and optimization of structural model, nine insignificant (p>0.05) paths from 'age', 'nationality', 'education institution', 'housing situation', 'living duration', 'mother education', 'father education', 'smoking status' and 'drinking status' to mental health in the "full" Model 1 were systematically dropped. By removing these pathways, the "trimmed" or "reduced" structural Model 1 that was statistically significant was created, thereby used for final analysis and interpretation.

4.1.1 Model fit

The goodness of fit of the original literature derived Model 1 and the 'trimmed' Model 1 is shown in Table 4.1. Several standardized fit statistics such as the deviance or model chi-square (χ^2; Kline, 1998a), the relative chi-square or normal chi-square (χ^2/df; Ullman; 2001), the root mean square error of approximation (RMSEA; Steiger, 1990), the goodness-of-fit index (GFI; Jöreskog and Sörbom, 1993, 1996), the adjusted goodness-of-fit index (AGFI; Tabachnick and Fidell, 2007), the normed fit index (NFI; Bentler and Bonnet, 1980) , the comparative fit index (CFI; Bentler, 1990), and the incremental fit index (IFI; Marsh, 1988) were tested to estimate how well the structural equation model performs. The chi-square value should not be significant and the relative chi-square should be 2 or less if there is a good model fit (Ullman, 2001). Besides, a good-fitting model is indicated by RMSEA less than 0.05, GFI, AGFI, NFI at or above 0.95, and CFI, IFI at or above 0.90 (Schumacker and Lomax, 2004; Garson, 2015). As can be seen in Table 4.1, the trimmed structural model appears to be a good fit to the data as all the standardized fit statistics achieved the threshold values (e.g. here χ^2/df =1.362 < 2, p > 0.05, RMSEA = 0.033 < 0.05, CFI = 0.986 > 0.90). Accordingly, no further post-hoc modification was conducted and the 'trimmed' Model 1 was made the final model for analyzing the use-frequency of green facilities in university students' neighborhoods.

Table 4.1
Goodness-of-fit indices of the original Model 1 and 'trimmed' Model 1:

| Model	χ^2	df	χ^2/df	p	RMSEA	GFI	AGFI	NFI	CFI	IFI
Original Model 1	695.513	122	5.701	0.000	0.117	0.827	0.757	0.361	0.387	0.407
'Trimmed' Model 1	19.072	14	1.362	0.162	0.033	0.988	0.961	0.953	0.986	0.987

There are two latent variables in the trimmed Model 1. Table 4.2 shows the regression weights between latent variables and the indicators and the squared multiple correlations of indicators. For latent variable 'social ties' which originally included six indicators with four indicating one's social contacts and two presenting social support, through the previous step CFA analysis, only two indicators about social support were left: a5, the extent that university students feel socially supported by their direct physical and social environment, and a6, the extent that people in university students' neighborhoods concerned with helping and supporting each other. The squared multiple correlation is the communality estimate for an indicator, which measures the percent of variance in a given indicator explained by its latent variable. It can also be interpreted as the reliability of the indicators (Garson, 2015). In this model, for example, the communality of indicator 'a5' is 0.506, suggesting that 50.6% of the variance in 'a5' is explained by the latent variable 'social ties'. The standardized regression weight for a5 and a6 are respectively 0.711 and 0.693 and are statistically significant. In terms of 'sense of community', the factor loadings for items a7 (the extent of agreement that living in their neighborhood gives university students a sense of community) and a8 (the computed average extent of agreement that university students feel at home, feel having bonds with people in their neighborhoods, feel a sense of connection with their neighborhood and feel walking around the neighborhood pleasant and convenient) are significant. 60.9% of the variance in indicator 'a7' and 67.6% in indicator 'a8' are explained by their latent variable 'sense of community'.

Table 4.2
Regression weights for latent variables and indicators:

	Regression weight	Standardized regression weight	Squared multiple correlations	P
Social ties				
a5 <--- Social ties	1.000	0.711	0.506	
a6 <--- Social ties	1.084	0.693	0.480	**0.000**
Sense of community				
a7 <--- Sense of community	1.000	0.781	0.609	
a8 <--- Sense of community	1.265	0.822	0.676	**0.000**

The final structural equation model ('trimmed' Model 1), displayed in Figure 4.1, includes the following seven variables: Use-frequency of green facilities in the neighborhood, university students' physical activity, social ties, sense of community about their living neighborhood, their mental health status, gender as well as their current financial status. It illustrates the relationships between these latent variables and manifest variables as well as the relationships between latent variables and their indicators. Directly measured variables or manifest variables and the indicators for latent variables are indicated by rectangles, while variables in ovals represent the latent variables. z1, z2, z3, z4, and z5 are the error terms for endogenous variables and e1, e2, e3, and e4 are the error terms for indicators of latent variables. The arrows in the figure indicate the pathways between the variables.
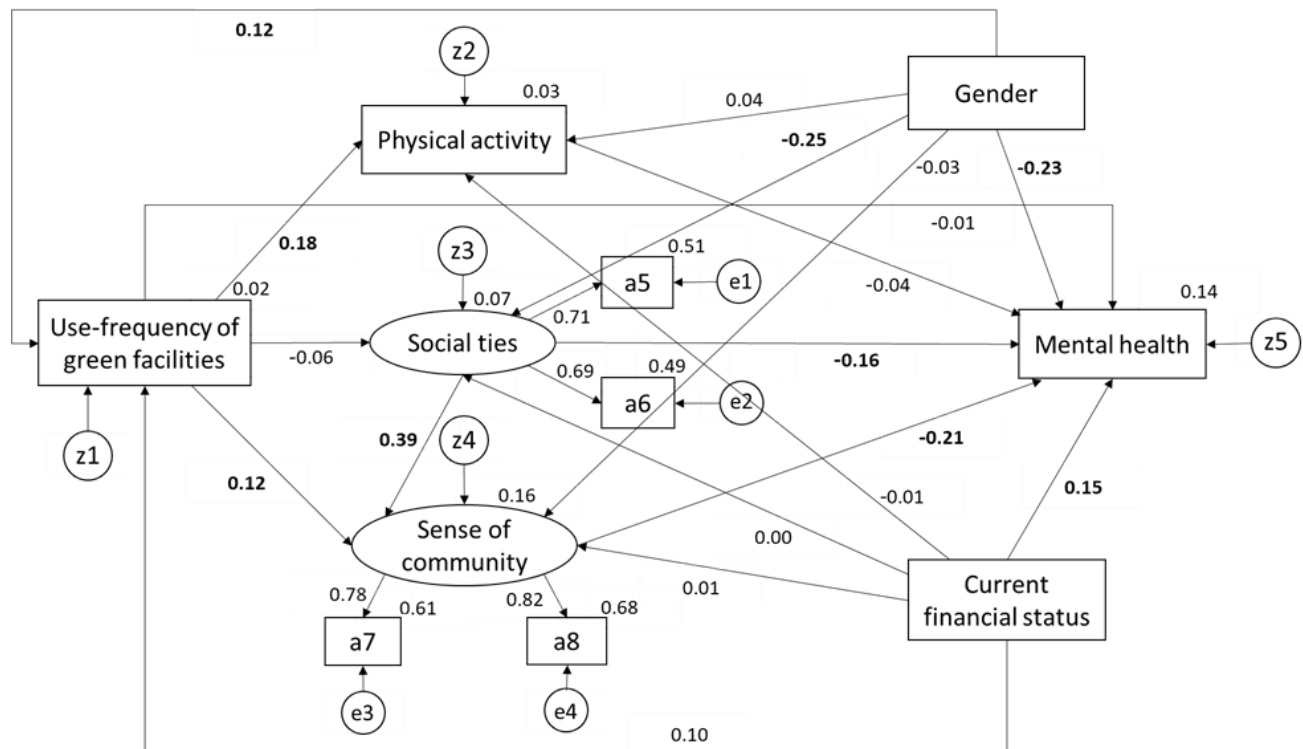
Figure 4.1. 'trimmed' model 1

Table 4.3 presents the squared multiple correlations (SMC) for the endogenous variables in the trimmed Model 1. The squared multiple correlation refers to the explained percent of variance in a given variable by the predictor variables in the model that has a direct effect upon it. In this model, only 2.4% of the variance in university students' use-frequency of green facilities in their neighborhoods is explained by students' gender and current financial status (see Figure 4.1). Similarly, students' gender, current financial status, and the use-frequency of green facilities in the neighborhood can only explain 3.5% of the variance in physical activity and 7% in social ties. The reason why the SMC for 'social ties' is so low could be because a5 and a6 only represent the social support part of social ties. The SMCs are higher for sense of community and mental health. The direct effects of university students' gender, current financial status, their use-frequency of green facilities in the neighborhood as well as social ties upon sense of community have explained 16.3% of its variance. Besides, Figure 4.1 shows that there are direct paths from all other exogenous and endogenous variables in the model to mental health, which help explain 14.3% of the variance of mental health.

Table 4.3
Squared multiple correlation for the trimmed Model 1:

	Use-frequency of green facilities	Physical Activity	Social ties	Sense of community	Mental health
Squared Multiple Correlations	0.024	0.035	0.070	0.163	0.143

4.1.2 Interpreting structural coefficients

The regression outcomes of the 'trimmed' Model 1 report the relationships of all variables used in the model in terms of direct, indirect, and total effects. Table 4.4 integrates the direct, indirect into total effects for both exogenous variables and endogenous variables to provide a comprehensive grasp; while the direct, indirect, and total effects on the indicators of latent variables are presented in Table 4.5.

4.1.2.1 direct effects

A direct effect represents the effect of an independent variable (can be exogenous or endogenous) on a dependent variable (endogenous), which is usually measured by the path coefficients. The regression weights or factor loadings of the pathways between variables (latent and latent variables, latent and manifest variables, manifest and manifest variables) indicate their structural relationships. It is worth noting that in this research university students' mental health was measured using scale SCL-10, thus a higher score represents greater mental illness and poorer mental health.

Demographic and socio-economic status

In this model, university students' use-frequency of green facilities in their neighborhood is significantly associated with their gender. Male students tend to utilize green facilities in their neighborhoods more frequently compared with female students. Unlikely, university students' current financial status appears to have no influence upon their use-frequency of green facilities. The association is shown to be weak and not significant as the p-value is a bit higher than the threshold value (0.05). In addition, university students' gender and current financial status both have been observed as significantly and strongly related to their mental health status. Mental disorders are more likely to occur among female university students and respondents who are in a difficult financial situation. It is likely to be case that students in a financial struggle tend to face more economic pressure that contributes to a higher possibility of showing the symptoms of depression and anxiety.

In terms of three intermediate mechanisms which are said theoretically to be associated with university students' gender and socio-economics status, however, in this trimmed Model 1, both physical activity and sense of community are found empirically significantly related with neither university students' gender nor current financial status. Similarly, current financial status also has no significant influence on university students' social ties, yet there is a strong connection found between students' gender and their social ties. Female university students tend to feel more socially supported by their environments and perceive people in their neighborhoods as more concerned with helping and supporting each other than male students.

Direct linkage

The direct effect of university students' use of green facilities in their neighborhoods on their mental health was examined through the direct pathway between the two variables in trimmed Model 1 (see Figure 4.1). Although the standardized regression weight of the pathway from the use-frequency of green facilities to mental health is negative, an insignificant direct association between the use-frequency of green facilities in university students' neighborhoods and their mental health has been found. Therefore, it can be interpreted that the frequency that students visit green facilities in the neighborhood itself cannot determine their mental health directly.

Physical activity

According to the literature, physical activity is a potential mediating mechanism between individuals' use-frequency of green facilities in the neighborhood and mental health. In this model, university students' use-frequency of green facilities in the neighborhood have been found to exert a strong and positive impact upon their physical activity. University students who visit green facilities in their neighborhoods more frequently are likely to spend more hours on performing activities like walking, cycling, sports etc., which refers to what previous studies found that green facilities in the living environment could invite people to be more physically active (Tzoulas et al., 2007). However, model estimation outcomes suggest that the correlation between the hours per week university students undertake physical activities and their mental health is not statistically significant. One probable explanation for this phenomenon may be that the intensity of physical activity undertaken interferes the relationship. Studies have suggested that physical activity needs to be moderate enough to exert a health benefit (Lee and Paffenbarger, 2000). Moreover, physical activity under certain intensity might be positively associated with mental health while exceeding that intensity level, physical activity might cause physical and mental burden thus resulting in a decline on individuals' mental health. Nevertheless, under this circumstance, we can say that for university students, their use-frequency of green facilities in their neighborhood is not likely to contribute to their mental health through influencing physical activity.

Social ties

Contrary to physical activity, a significant effect of university students' social ties upon their mental health status is observed. In line with substantial evidence in many previous studies of general population indicating that social ties are beneficial for mental health (e.g. Uchino et al., 2001), it is suggested that the more socially supported by their environments students feel as well as the more concerned with helping and supporting each other that people in their neighborhoods are, the healthier university students are mentally. Nevertheless, students' social ties turn out to be insignificantly associated with their use-frequency of green facilities in their neighborhoods. The appearance of such an outcome may result from the measurement of social ties. Due to the unidimensionality requirement of a measurement model, only two indicators concerning social support were remained to represent social ties, whereas most university students live in a rented student house, rather than from neighbors, their social support is more likely to be acquired from their friends or families that are not necessary living in the same neighborhoods as those students. Nonetheless, in this model, the possibility of social ties as an intermediate mechanism behind university students' use-frequency of green facilities in the neighborhood and their mental health has

been denied, different from what was found in the literature that social ties were able to mediate between green facilities and mental health.

Sense of community

In terms of 'sense of community', the trimmed Model 1 tested its association with students' use-frequency of green facilities in the neighborhood and a significant positive correlation is revealed, indicating that a higher sense of community towards the neighborhood is more often found among students who tend to visit green facilities in their neighborhoods. On the other hand, the pathway from 'sense of community' to 'mental health' in the trimmed Model 1 is also significant. The negative standardized regression weight of this path (value: -0.211) suggests that students' sense of community towards their neighborhoods has a negative effect on the extent of their mental illness. Students with higher sense of community are likely to be mental healthier than those with lower sense of community, and an increase on university students' sense of community is associated with a decline of their depression and anxiety symptom scales. Accordingly, in line with the discussion in the literature review section, there is a significant indirect connection between university students' use-frequency of green facilities and their mental health through their sense of community. The beneficial effect of university students' use-frequency of green facilities in their neighborhoods on mental health operates through the intermediate mechanism—sense of community. In addition, consistent with the literature presenting a connection between social ties and sense of community, the regression results in Table 4.4 have shown that social ties are strongly and positively related to sense of community. A higher level of social ties tends to be accompanied by a higher sense of community towards the neighborhood among university students.

4.1.2.2 indirect and total effects

One of the main purposes of this study is to examine whether and to what extent physical activity, social ties and sense of community are able to mediate the association between green facilities and university students' mental health. Structural equation modeling provides an analysis not only on direct effects but also indirect effects and total effects between variables. Through considering the indirect significant paths in the model, whether the effect of a variable on another variable is mediated or accounted for by intervening variables can be identified.

Indirect effects

An indirect effect represents the effect of an independent variable (can be exogenous or endogenous) on a dependent variable (endogenous) through a mediating or several mediating variables (Baron and Kenny, 1986). In addition to the direct effect, the 'trimmed' Model 1 contains a number of indirect paths leading to indirect effects to several endogenous variables. Take physical activity as an example, from the Figure 4.1 we can see that there is a direct path from university students' gender to their physical activity level. Moreover, gender has a significant indirect effect on physical activity through exerting an influence on one's use-frequency of green facilities in the neighborhood. Similarly, an indirect path from current financial status to physical activity through the use-frequency of green facilities in the neighborhood is

displayed in Figure 4.1. However, Table 4.4 shows that this indirect pathway is not significant and the influential extent is extremely small. For sense of community, the direct effect of university students' gender is found not significant while it has a significant indirect effect on sense of community, which means that gender itself cannot influence students' sense of community to the neighborhood, but, it can exert an influence on their use-frequency of green facilities in the neighborhood, thus indirectly impacts students' sense of community through the facilitation of use-frequency of green facilities on sense of community. The indirect effect of students' use-frequency of green facilities in the neighborhood on the sense of community turns out insignificant.

As for mental health, both one exogenous variable and one endogenous variable are identified to have an indirect effect on it. The direct effect of university students' gender on their mental health suggests that male students tend to have a better mental health and are less mentally ill than female students. Conversely, the estimate for indirect effect of gender on mental health shown in Table 4.4 is positive, indicating that from the perspective of indirect effect, female students are able to improve their mental health through their higher frequency of visits to green facilities, their stronger social ties, as well as their higher level of sense of community, which all in a certain extent benefit their mental health status. The endogenous variable that has a significant indirect effect on mental health is 'social ties'. Directly university students' social ties are discovered to have a significant influence on their mental health. In addition, as there is an association between social ties and sense of community, social ties hence have the ability to indirectly benefit students' mental health through exerting a positive impact on their sense of community towards their neighborhoods. For the use-frequency of green facilities, although it has been discovered to exert a significant indirect positive impact upon university students' mental health by improving students' sense of community towards their neighborhoods, the indirect pathways through physical activity and social ties are not significant. Therefore, it turns out that no overall indirect effect of use-frequency of green facilities in students' neighborhoods has been found on their mental health.

Total effects

The total effect for a variable is the summarization of the direct and indirect effects of this variable on a dependent variable (endogenous). Table 4.4 and Table 4.5 display the total effects of two exogenous variables and four endogenous variables on the use-frequency of green facilities in the neighborhood, physical activity, social ties, sense of community, mental health, and four indicators of latent variables: social ties and sense of community in the trimmed Model 1. As an endogenous variable, university students' use-frequency of green facilities in their neighborhoods is only linked with their gender and current financial status directly, which can be seen in Figure 4.1. Therefore, the total effects of gender and current financial status are also the direct effects. Table 4.4 shows that male students tend to use green facilities in their neighborhoods more often, while students' financial status has no significant total effect on their use-frequency of green facilities.

Considering students' physical activity level, two exogenous variables: gender and current financial status turn out to have no significant total effects on it. However, a significant positive total effect of the use-

frequency of green facilities on physical activity has been found. If students use green facilities in their neighborhoods more often, their physical activity levels tend to be higher. On the other hands, no significant total effects of university students' use-frequency of green facilities in their neighborhoods on their social ties and sense of community towards the neighborhood is reported. But it appears that students' gender has a significant total effect on social ties, and that male students are more likely to have weaker social ties than female students. As there is an association between university students' social ties and sense of community (path from 'social ties' to 'sense of community' in Figure 4.1), social ties are also discovered to have a significant positive total effect on sense of community.

Variables that have a significant total effect on mental health include two exogenous variables in the trimmed Model 1: gender and current financial status, as well as two endogenous variables: social ties and sense of community. For variable 'gender', its direct influence on 'mental health' is shown to be negative while the indirect influence appears to be the opposite. However, overall, 'gender' is negatively associated with 'mental health'. Male students in general tend to have better mental health than female students. The other exogenous variable 'current financial status' is found to have a significant positive total effect upon mental health. Students in a financial struggle are usually accompanied by poorer mental health. With regard to endogenous variables, a significant total effect of both social ties and sense of community upon university students' mental health is discovered. An increase on university students' social ties or sense of community is likely to contribute to an improvement of the level of mental health. Concerning university students' use-frequency of green facilities in their neighborhoods, although it can indirectly improve students' mental health status by facilitating a sense of community towards their neighborhoods, inconsistent with previous findings in general population suggesting that the frequency that people use green facilities in their neighborhoods could bring about mental health profits (e.g. Nielsen and Hansen, 2007), as shown in Table 4.4, no significant overall effect on university students' mental health has been found.

Table 4.4

The trimmed Model 1: direct, indirect, total effects

		Use of green	Physical Activity	Social ties	Sense of community	Mental health
Exogenous variables						
Male	Direct	*0.121**	0.043	**-0.251****	-0.028	*-0.230***
	Indirect	--	*0.021**	-0.007	*-0.085***	*0.061**
	Total	*0.121**	0.064	*-0.259***	-0.113	*-0.169***
Financial struggle	Direct	0.096	-0.009	0.005	0.011	*0.152**
	Indirect	--	0.017	-0.006	0.011	-0.005
	Total	0.096	0.008	-0.001	0.023	*0.147**
Endogenous variables						
Use of green	Direct	--	**0.177***	-0.060	*0.124**	-0.005
	Indirect	--	--	--	-0.023	-0.019
	Total	--	*0.177**	-0.060	0.100	-0.025
Physical activity	Direct	--	--	--	--	-0.044
	Indirect	--	--	--	--	--
	Total	--	--	--	--	-0.044
Social ties	Direct	--	--	--	*0.388***	*-0.157**
	Indirect	--	--	--	--	*-0.082***
	Total	--	--	--	*0.388***	*-0.239***
Sense of community	Direct	--	--	--	--	*-0.211***
	Indirect	--	--	--	--	--
	Total	--	--	--	--	*-0.211***

Note: "use of green" refers to "the use-frequency of green facilities in the neighborhood". * p<0.05, ** p<0.01

Table 4.5

The trimmed Model 1: direct, indirect, total effects: for indicators

		a5	a6	a7	a8
Exogenous variables					
Male	Direct	--	--	--	--
	Indirect	*-0.184***	*-0.179***	-0.088	-0.093
	Total	*-0.184***	*-0.179***	-0.088	-0.093
Financial struggle	Direct	--	--	--	--
	Indirect	-0.001	-0.001	0.018	0.019
	Total	-0.001	-0.001	0.018	0.019
Endogenous variables					
Use of green	Direct	--	--	--	--
	Indirect	-0.043	-0.042	0.078	-0.042
	Total	-0.043	-0.042	0.078	0.082
Physical activity	Direct	--	--	--	--
	Indirect	--	--	--	--
	Total	--	--	--	--
Social ties	Direct	*0.711***	*0.693***	--	--
	Indirect	--	--	*0.303***	*0.319***
	Total	*0.711***	*0.693***	*0.303***	*0.319***
Sense of community	Direct	--	--	*0.781***	*0.822***
	Indirect	--	--	--	--
	Total	--	--	*0.781***	*0.822***

Note: "a5" refers to "the extent that university students feel socially supported by their direct physical and social environment"; "a6" refers to "the extent that people in university students' neighborhoods concerned with helping and supporting each other"; "a7" refers to "the extent of agreement that living in their neighborhood gives university students a sense of community"; and "a8" represents "the computed average extent of agreement that university students feel at home, feel having bonds with people in their neighborhoods, feel a sense of connection with their neighborhood and feel walking around the neighborhood pleasant and convenient". * p<0.05, ** p<0.01.

4.2. Proportion of green facilities and mental health

Structural equation models: Model 2.1 and Model 2.2 were carried out to examine the association between the proportion of green facilities in university students' neighborhoods and their mental health. Model 2.1 and Model 2.2 have the same structural paths and measurement models. The only difference of these two models is that the data about the variable: the proportion of green facilities in the neighborhood. In Model 2.1 the proportion of green facilities in university students' neighborhoods was derived from land-use database LGN7, while Model 2.2 applied the data extracted from database BBG2012. The "Maximum Likelihood Estimates" method was conducted for in AMOS for these two models and their outcomes were compared to minimize the interference of the application of different land-use databases.

4.2.1 Model fit

Table 4.6 reports the goodness of fit of Model 2.1 and Model 2.2. The various fit statistics used here to judge the adequacy of the model suggest that these original literature-derived models didn't provide a good model fit. For both original models, the chi-square values were significant (p<0.05), which means the covariance structure of the given model is significantly different from the observed covariance matrix, indicating a poor model fit. Therefore, to modify the models, same as what was done for Model 1, each path that from the control variables to 'mental health' that didn't meet the significance threshold (p<0.05) was removed. Accordingly, variables including 'age', 'nationality', 'education institution', 'housing situation', 'living duration', 'mother education', 'father education', 'smoking status' and 'drinking status' were dropped from the models, and two new models: the trimmed Model 2.1 and the trimmed Model 2.2 (see Figure 4.2, 4.3) that met the statistical significance requirement were created for interpretation. The goodness-of-fit indices in Table 4.6 shows that the trimmed Model 2.1 and the trimmed Model 2.2 both provide a good fit to the validation data. For trimmed Model 2.2, χ^2 = 19.510, df = 16, p = 0.243, CFI = 0.990, RMSEA = 0.025 (remainder indices can be found in Table 4.6), all indices have reached the recommended thresholds. The trimmed Model 2.1 performs slightly better than the trimmed Model 2.1 (the AIC for trimmed Model 2.1 is 76.443, lower than 77.510 of trimmed Model 2.2), the goodness-of-fit indices are also slightly higher than those of trimmed Model 2.1.

For the measurement models in two trimmed structural models, after CFA analysis, latent variable 'social ties' includes only two indicators about social support: a5 and a6. From Table 4.7 we can see that the measurement models in these two models perform quite similar. The standardized regression weights of the four indicators a5, a6, a7, and a8, for instance, are statistically significant and have similar values. In trimmed Model 2.1 the factor loading for indicator a5 is 0.719 while in trimmed Model 2.2 the factor loading is 0.715. Besides, Table 4.7 displays the squared multiple correlations for indicator variables. In trimmed Model 2.1, the communality of the indicator a5 and a6 is respectively 0.518 and 0.469, meaning that the reliability of a5 and a6 as an indicator of 'social ties' is said to be 0.518 and 0.469. 61.4% of the variance in the indicator a7 and 67.1% in a8 can be explained by the latent variable 'sense of community'. The trimmed Model 2.2 shows a similar community for indicators a5, a6, a7 and a8 as the trimmed Model 2.1, representing a similar level of reliability of the indicators for latent variables 'social ties' and 'sense of community'.

Table 4.6
Goodness-of-fit indices of the original Model 2.1, 2.2 and trimmed structural Model 2.1, 2.2:

Model	χ^2	df	χ^2/df	p	RMSEA	GFI	AGFI	NFI	CFI	IFI
Original Model 2.1	740.642	124	5.973	0.000	0.121	0.816	0.746	0.338	0.316	0.380
'Trimmed' Model 2.1	18.443	16	1.153	0.299	0.021	0.988	0.967	0.953	0.993	0.993
Original Model 2.2	753.675	124	6.078	0.000	0.122	0.807	0.734	0.330	0.352	0.371
'Trimmed' Model 2.2	19.510	16	1.219	0.243	0.025	0.988	0.966	0.950	0.990	0.991

Table 4.7
Regression weights for latent variables and indicators

		Standardized regression weight	Squared multiple correlations	P
Trimmed Model 2.1	*Social ties*			
	a5 <--- Social ties	0.719	0.518	
	a6 <--- Social ties	0.685	0.469	**0.000**
	Sense of community			
	a7 <--- Sense of community	0.784	0.614	
	a8 <--- Sense of community	0.819	0.671	**0.000**
Trimmed Model 2.2	*Social ties*			
	a5 <--- Social ties	0.715	0.511	
	a6 <--- Social ties	0.689	0.475	**0.000**
	Sense of community			
	a7 <--- Sense of community	0.796	0.634	
	a8 <--- Sense of community	0.806	0.650	**0.000**

Note: "a5" refers to "the extent that university students feel socially supported by their direct physical and social environment"; "a6" refers to "the extent that people in university students' neighborhoods concerned with helping and supporting each other"; "a7" refers to "the extent of agreement that living in their neighborhood gives university students a sense of community"; and "a8" represents "the computed average extent of agreement that university students feel at home, feel having bonds with people in their neighborhoods, feel a sense of connection with their neighborhood and feel walking around the neighborhood pleasant and convenient".

Figure 4.2 and Figure 4.3 present the final structural equation models: the trimmed Model 2.1 and trimmed Model 2.2. The proportion of green facilities in university students' neighborhood is an exogenous variable. Manifest variables and the indicators for latent variables are indicated by rectangles, while variables in ovals represent the latent variables. z2, z3, z4, and z5 are the error terms for endogenous variables: physical activity, social ties, sense of community and mental health. e1, e2, e3, and e4 are the error terms for four indicators of latent variables: a5, a6, a7 and a8. The arrows in the figures indicate the pathways between the variables. Although these two models have the same measurement model and structural paths, the parameter estimates are different.
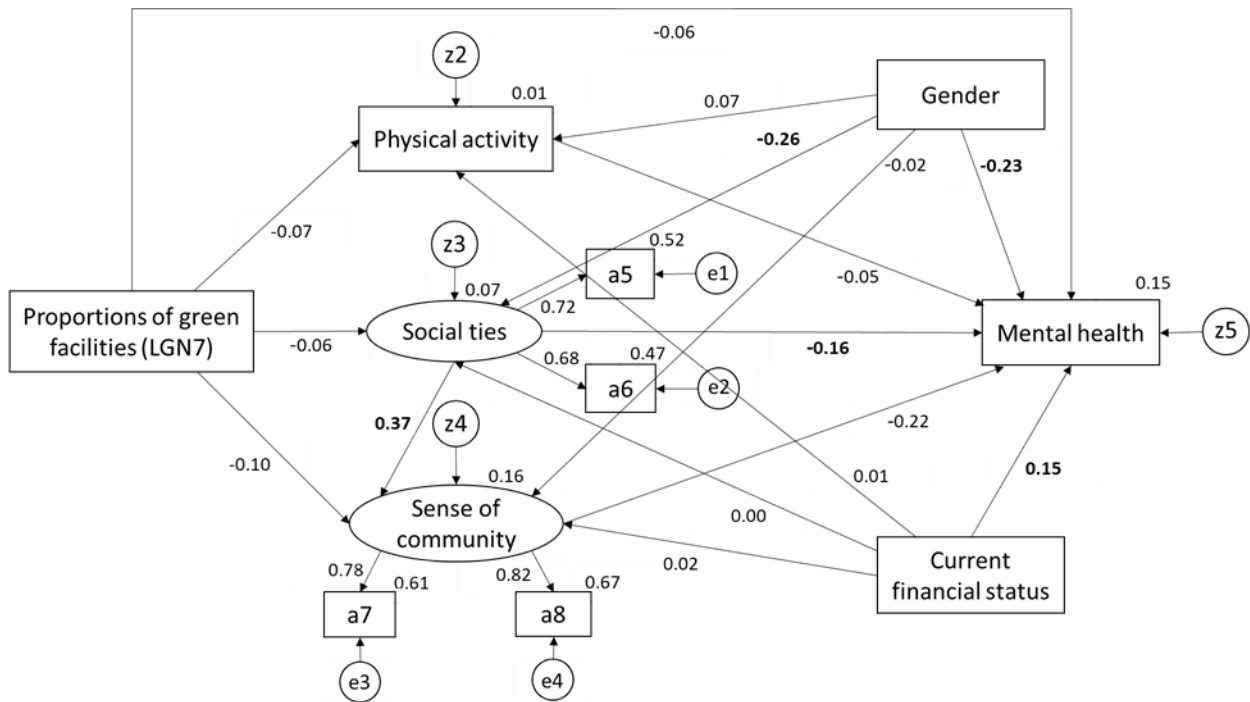
Figure 4.2 the 'trimmed' Model 2.1
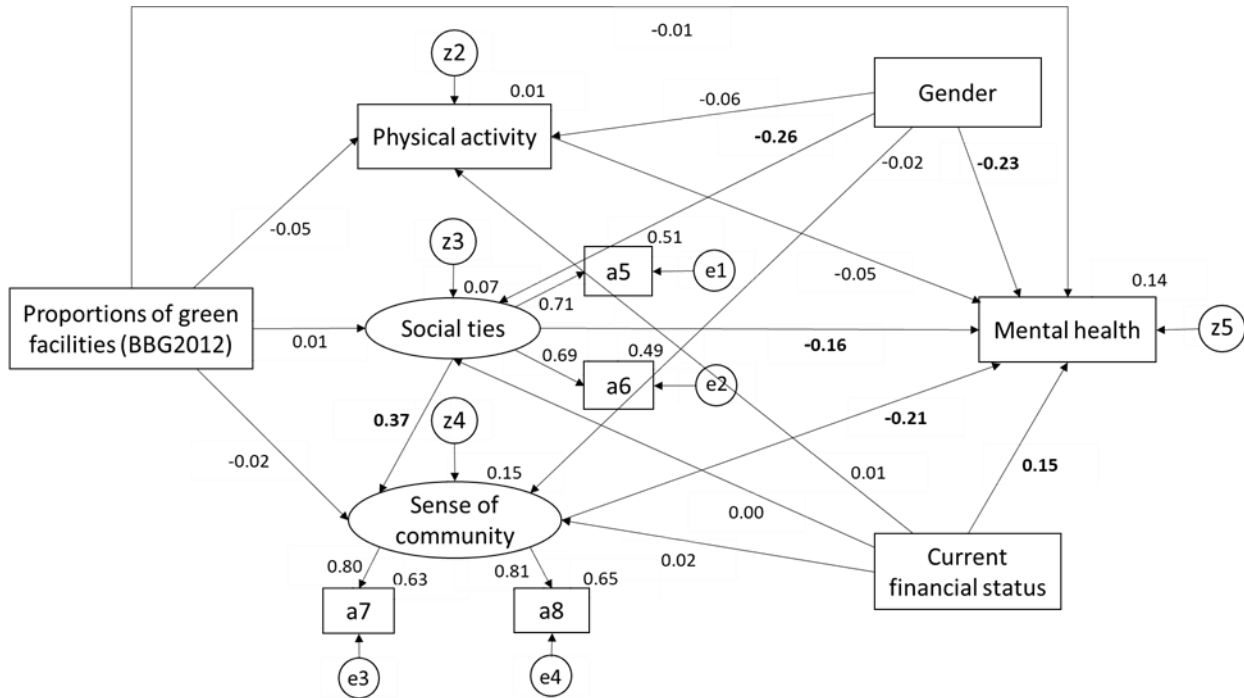
Figure 4.3 the 'trimmed' Model 2.2

The squared multiple correlations for endogenous variables: physical activity, social ties, sense of community and mental health in trimmed Model 2.1 and 2.2 are displayed in Table 4.8. Similar to the trimmed Model 1, only a small percentage of variance in physical activity (less than 1%) is explained by the predictor variables with a direct effect on it in both models (see Figure 4.2 and 4.3). Besides, the squared multiple corrections for 'social ties' and 'sense of community' in two models are respectively around 0.07 and 0.15, suggesting around 7% of latent variable 'social ties' and 15% of latent variable 'sense of community' are explained by the direct effects of related variables upon them. As for mental health, in the trimmed Model 2.1, 14.7% of its variance is explained by the predictor variables including students' gender and current financial status, the proportion of green facilities in university students' neighborhoods, physical activity, social ties, and sense of community; whereas 14.4% of the variance in mental health has been explained in trimmed Model 2.2.

Table 4.8
Squared multiple correlation for trimmed Model 2.1 and 2.2:

		Physical Activity	Social ties	Sense of community	Mental health
SMC	Trimmed Model 2.1	0.009	0.071	0.156	0.147
	Trimmed Model 2.2	0.006	0.067	0.147	0.144

4.2.2 Interpreting structural coefficients

Given an adequate fit of the models to the data, the next procedure is to interpret the regression results. The aim of conducting the trimmed Model 2.1 and trimmed Model 2.2 is to provide empirical evidence for the influence of the proportion of green facilities in university students' neighborhoods upon their mental health status. The regression results of the trimmed Model 2.1 and trimmed Model 2.2 are compared to lessen the deviations caused by the utilization of difference resources of land-use databases as far as possible. The direct, indirect, and total effects of the associations of all the variables in the trimmed Model 2.1 can be found in Table 4.9 and Table 4.10. Table 4.11 and Table 4.12 display the direct, indirect, and total effects for trimmed Model 2.2.

4.2.2.1 direct effects

The interpretation of direct effects is elaborated from the following five aspects: demographic and socio-economic status, direct exposure, physical activity, social ties, and sense of community. In this research university students' mental health is measured using scale SCL-10, thus a higher score in variable 'mental health' represents greater metal illness and poorer mental health.

Demographic and socio-economic status

In both the trimmed Model 2.1 and the trimmed Model 2.2, the paths from the university students' gender and current financial status to their mental health show similar significant factor loadings respectively. From gender to mental health, the path coefficients are equally -0.232 for two models, suggesting that in comparison with female students, male students tend to have a better mental health and experience lower level of depression and anxiety. This finding is contrary to what Eisenberg et al. (2007) found in their study that female undergraduates tended to screen more positively for anxiety and for major depression. As for current financial status, it has shown a strong positive impact on university students' mental health in both two models (path coefficient for trimmed Model 2.1: 0.153, for trimmed Model 2.2: 0.151). That is to say, university students who are in a financial struggle are more likely to suffer from poorer mental health, which is consistent with the previous findings both in mental health studies of general population (e.g. Yu and Williams, 1999) and university students (Eisenberg et al., 2007).

Considering the theoretically derived three mediating mechanisms, in contrary to what was expected that male students would have a higher physical activity level than female students, university students' gender and current financial status both have no significant association with their physical activity level and sense of community to their neighborhoods in these two models. Regarding to social ties, it turns out that students' financial status also has no significant impact on their social ties. However, university students' gender has been found to be significantly related to their social ties. The factor loading of the path from gender to social ties (in both models: -0.259) suggests that female students tend to have stronger social ties than males. These findings concerning the demographic and socio-economic status are consistent with what has been found in the trimmed Model 1.

Direct exposure

The impact of green facilities on mental health through the restorative experiences of nature by virtue of immersion within green spaces was examined in this research by the direct path from the proportion of green facilities in the neighborhood to mental health. In both trimmed Model 2.1 and trimmed Model 2.2, although as expected that the path coefficient is negative, showing that an increase of the amount of green facilities in the neighborhood might contribute to a higher level of mental health, the association turns out insignificant (p=0.240). Therefore, based on the regression outcomes, the mental restoration effect of exposure to green cannot help explain the association between green facilities in the neighborhood and university students' mental health.

Physical activity

Physical activity is a literature derived intermediate mechanism behind green facilities and mental health. However, not only in the trimmed Model 2.1, but also in the trimmed Model 2.2, the time university students spend on physical activity appears to have no significant impact on mental health. One probable factor that may have interfered the relationship between students' physical activity and their mental health could be the intensity of physical activities students undertook, which was mentioned previously in the trimmed Model 1 that the effect of the activity intensity may not be linear but curvilinear. In addition, according to the regression outcomes, university students' physical activity level is not significantly influenced by the proportion of green facilities in students' living neighborhoods. It could be the reason that university students are more likely to conduct their physical exercises inside the gyms rather than in the green facilities. Besides, this research concentrates on investigating the green facilities in students' living neighborhoods, but it could be possible that some university students choose to undertake physical activity in green facilities outside their neighborhoods (such as in the campus) more often than inside the neighborhoods out of the facility quality consideration.

Social ties

Similarly, although social ties have been identified in the literature review section as a potential factor mediating the association between green facilities and mental health, the structural equation modeling reveals contradictory results. In both two models whose variable—the proportion of green facilities in the neighborhood—was measured using different land-use databases, no significant paths occur from the proportion of green facilities in the neighborhood to social ties. This unexpected outcome might be caused by the indicators of latent variable 'social ties' as they only represent the social support part, which was also mentioned in the previous section when interpreting the trimmed Model 1. But it could also be that the amount of green facilities in the neighborhood simply doesn't have any influence on university students' social ties. University students' social ties might not be limited in the sphere of green facilities or even neighborhood but reach out to the campus, the gym etc. other places outside living neighborhoods. On the other hand, the path from social ties to mental health appears significant. Consistent with what previous studies have claimed that social ties are recognized as having a salutary impact on mental health (e.g. Kawachi and Berkman, 2001; Leyden, 2003), the similar negative path

coefficients in trimmed Model 2.1 (-0.159) and trimmed Model 2.2 (-0.156) indicate that stronger social ties are corresponded with less mental illness symptoms.

Sense of community

As for sense of community, like social ties, the proportion of green facilities in university students' neighborhoods turns out to have no influence on their sense of community towards their neighborhoods, which is unexpected because according to the literature, natural features and green open spaces are supposed to contribute to residence's sense of community scales towards their neighborhoods (e.g. Kim and Kaplan, 2004; Flap and Völker, 2005). One possible explanation could be that the quality of green facilities in the neighborhood played a role. Low quality of green facilities in student's neighborhoods may not even be able to attract university students' visits let alone assisting developing a sense of community. Concerning the association between sense of community and mental health, the standardized factor loadings of the two models (though negative in numbers: -0.219 for trimmed Model 2.1 and -0.214 for trimmed Model 2.2) both present a significantly positive effect of university students' sense of community on their mental health, suggesting that a higher sense of community is related to a lower risk of mental illness, which offers support for the findings in previous studies that sense of community is conducive to mental health (e.g. Ellaway et al., 2001; Dumont, 2002). Even though, due to the insignificant linkage between the proportion of green facilities and sense of community, sense of community cannot be regarded as mediating between the proportion of green facilities in university students' neighborhoods and their mental health.

In trimmed Model 2.1 and Model 2.2, the path from social ties to sense of community is significantly positive as expected, suggesting that in line with the literature, university students with stronger social ties tend to have a higher sense of community towards their neighborhoods. This finding presents empirical evidence for the salutary effect of social ties on sense of community.

4.2.2.2 indirect and total effects

To figure out to what extent the proportion of green facilities in university students' living neighborhoods is associated with their mental health and to what extent this association is mediated through physical activity, social ties and sense of community, the indirect and total effects between the variables in both the trimmed Model 2.1 and Model 2.2 were examined and are interpreted as follows.

Indirect effects

Figure 4.2 and Figure 4.3 show that besides the direct effects, the trimmed Model 2.1 and Model 2.2 contain several indirect pathways to university students' sense of community and mental health. In the trimmed Model 2.1, for instance, gender has shown to have a significantly negative indirect effect on sense of community by exerting an influence on social ties which have been found positively associated with sense of community. In other words, in comparison with females, male students have less strong

social ties, thereby leading to a lower level of sense of community towards their neighborhoods. In addition, university students' gender is also found to indirectly affect their mental health. The standardized indirect effect (0.063) suggests that from an indirect influence point of view, male students tend to have poorer mental health than females, which contradicts the direct effect of gender showing that male students are mentally healthier.

As an exogenous variable, although the proportion of green facilities in university students' neighborhoods have been found to exert no direct impact on their mental health status, however, a significant indirect influence of proportion of green facilities on mental health in the trimmed Model 2.1 is discovered. It is worth noting that the indirect influence is rather weak and the value of indirect effect is very small (0.039), which means that for each standard deviation increase in the proportion of green facilities in the neighborhood, students' SCL-10 value decreases only by 0.039 standard deviation. Out of three endogenous variables, only one indirect pathway has been found from social ties to mental health and it appears to be significant. University students' social ties are able to not only directly improve their mental health status but also indirectly exerting a conducive effect on their sense of community towards their neighborhoods, thus contributing to an improvement of their mental health.

In the trimmed Model 2.2, the indirect effects on university students' sense of community towards their living neighborhoods, and on their mental health perform similar to trimmed Model 2.1 from the aspect of both the effect score and significance level. However, the proportion of green facilities in the neighborhood measured by BBG2012 database shows no significant indirect effect on university student' mental health, which is different from what was found in the trimmed Model 2.1. This divergence might result from the different classification criteria of green areas in LGN7 and BBG. But since in trimmed Model 2.1 the indirect influence is rather weak, the regression outcomes of these two models remain consistent with each other.

Total effects

Table 4.9 and Table 4.11 display the total effects of manifest and latent variables in the trimmed Model 2.1 and Model 2.2. In both models, there are no significant total effects of exogenous variables discovered on physical activity and sense of community. Although university students' gender has shown a significant indirect impact upon their sense of community towards their neighborhoods, the direct effect of gender stays insignificant, resulting in an insignificant total effect as the summarization of direct and indirect effects on sense of community. As for mental health, university students' gender and current financial status both have a significant total effect on their mental health. The overall total effect of gender on mental health in the two models suggests that male university students have a better mental health than females. Students suffering from a financial struggle tend to experience a higher scale of mental illness symptoms. The overall effect of another exogenous variable—the proportion of green facilities in students' living neighborhoods on their mental health, which is of primary interest, has been found insignificant and the estimate is small (-0.021).

The total effects of three intermediate variables: physical activity, social ties, and sense of community upon mental health were examined in this research. In both the trimmed Model 2.1 and Model 2.2, the time university students spend on physical activities appears to have no total effect on their mental health. However, consistent with the literature, strong significant total effects of social ties and sense of community on university students' mental health have been discovered in both models. Generally speaking, students who are more socially supported by their direct physical and social environments and more likely to feel neighbors concerned with helping and supporting each other tend to have a better mental health. And a rise on students' sense of community towards their neighborhoods is usually associated with an improvement of their mental health status, which support the findings in previous literature that social ties and sense of community are of benefit to mental health (e.g., Kawachi and Berkman, 2001; Dumont, 2002).

Table 4.9
The trimmed Model 2.1: direct, indirect, total effects:

		Physical activity	Social ties	Sense of community	Mental health
Exogenous variables					
Male	Direct	0.065	*-0.259***	-0.015	*-0.232***
	Indirect	--	--	*-0.096***	*0.063**
	Total	0.065	*-0.259***	-0.111	*-0.169***
Financial struggle	Direct	0.009	0.002	0.024	*0.153**
	Indirect	--	--	0.001	-0.006
	Total	0.009	0.002	0.024	*0.147**
Proportion of green	Direct	-0.067	-0.057	-0.101	-0.060
	Indirect	--	--	-0.021	*0.039**
	Total	-0.067	-0.057	-0.122	-0.021
Endogenous variables					
Physical activity	Direct	--	--	--	-0.048
	Indirect	--	--	--	--
	Total	--	--	--	-0.048
Social ties	Direct	--	--	*0.371***	*-0.159**
	Indirect	--	--	--	*-0.081***
	Total	--	--	*0.371***	*-0.240***
Sense of community	Direct	--	--	--	*-0.219***
	Indirect	--	--	--	--
	Total	--	--	--	*-0.219***

Note: "proportion of green" refers to "the proportion of green facilities in the neighborhood". * p<0.05, ** p<0.01

Table 4.10

The trimmed Model 2.1: direct, indirect, total effects for indicators:

		a5	a6	a7	a8
Exogenous variables					
Male	Direct	--	--	--	--
	Indirect	*-0.187***	*-0.178***	-0.087	-0.091
	Total	*-0.187***	*-0.178***	-0.087	-0.091
Financial struggle	Direct	--	--	--	--
	Indirect	0.001	0.001	0.019	0.020
	Total	0.001	0.001	0.019	0.020
Proportion of green	Direct	--	--	--	--
	Indirect	-0.041	-0.039	-0.096	-0.100
	Total	-0.041	-0.039	-0.096	-0.100
Endogenous variables					
Physical activity	Direct	--	--	--	--
	Indirect	--	--	--	--
	Total	--	--	--	--
Social ties	Direct	*0.719***	*0.685***	--	--
	Indirect	--	--	*0.290***	*0.304***
	Total	*0.719***	*0.685***	*0.290***	*0.304***
Sense of community	Direct	--	--	*0.784***	*0.819***
	Indirect	--	--	--	--
	Total	--	--	*0.784***	*0.819***

Note: "proportion of green" refers to "the proportion of green facilities in the neighborhood"; "a5" refers to "the extent that university students feel socially supported by their direct physical and social environment"; "a6" refers to "the extent that people in university students' neighborhoods concerned with helping and supporting each other"; "a7" refers to "the extent of agreement that living in their neighborhood gives university students a sense of community"; and "a8" represents "the computed average extent of agreement that university students feel at home, feel having bonds with people in their neighborhoods, feel a sense of connection with their neighborhood and feel walking around the neighborhood pleasant and convenient". * $p < 0.05$, ** $p < 0.01$.

Table 4.11

The trimmed Model 2.2: direct, indirect, total effects

		Physical Activity	Social ties	Sense of community	Mental health
Exogenous variables					
Male	Direct	0.063	*-0.259***	-0.019	*-0.232***
	Indirect	--	--	*-0.098***	*0.063**
	Total	0.063	*-0.259***	-0.116	*-0.170***
Financial struggle	Direct	0.008	0.000	0.019	*0.151**
	Indirect	--	--	0.000	-0.004
	Total	0.008	0.000	0.019	*0.147**
Proportion of green	Direct	-0.046	0.011	-0.016	-0.014
	Indirect	--	--	0.004	0.003
	Total	-0.046	0.011	-0.012	-0.011
Endogenous variables					
Physical activity	Direct	--	--	--	-0.046
	Indirect	--	--	--	--
	Total	--	--	--	-0.046
Social ties	Direct	--	--	*0.377***	*-0.156**
	Indirect	--	--	--	*-0.081***
	Total	--	--	*0.377***	*-0.237***
Sense of community	Direct	--	--	--	*-0.214***
	Indirect	--	--	--	--
	Total	--	--	--	*-0.214***

Note: "proportion of green" refers to "the proportion of green facilities in the neighborhood". * $p<0.05$, ** $p<0.01$

Table 4.12

The trimmed Model 2.2: direct, indirect, total effects: for indicators

		a5	a6	a7	a8
Exogenous variables					
Male	Direct	--	--	--	--
	Indirect	*-0.185***	*-0.179***	-0.093	-0.094
	Total	*-0.185***	*-0.179***	-0.093	-0.094
Financial struggle	Direct	--	--	--	--
	Indirect	0.000	0.000	0.015	0.016
	Total	0.000	0.000	0.015	0.016
Proportion of green	Direct	--	--	--	--
	Indirect	0.008	0.008	-0.009	-0.009
	Total	0.008	0.008	-0.009	-0.009
Endogenous variables					
Physical activity	Direct	--	--	--	--
	Indirect	--	--	--	--
	Total	--	--	--	--
Social ties	Direct	*0.715***	*0.689***	--	--
	Indirect	--	--	*0.300***	*0.304**
	Total	*0.715***	*0.689***	*0.300***	*0.304**
Sense of community	Direct	--	--	*0.796***	*0.806***
	Indirect	--	--	--	--
	Total	--	--	*0.796***	*0.806***

Note: "a5" refers to "the extent that university students feel socially supported by their direct physical and social environment"; "a6" refers to "the extent that people in university students' neighborhoods concerned with helping and supporting each other"; "a7" refers to "the extent of agreement that living in their neighborhood gives university students a sense of community"; and "a8" represents "the computed average extent of agreement that university students feel at home, feel having bonds with people in their neighborhoods, feel a sense of connection with their neighborhood and feel walking around the neighborhood pleasant and convenient". * p<0.05, ** p<0.01.

5. Conclusions and discussion

This research addressed an issue of practical importance by examining a sample of university students in Utrecht to determine the influence of green facilities on university students' mental health. The objectives of this study are to investigate the impact of both the proportion of various green facilities around university students' living neighborhoods and their use-frequency of these green facilities on their mental health and examine the underlying mechanisms behind these two associations respectively. By testing it comprehensively using structural equation modeling, this report brings about an improved understanding of university students' mental health and the ways in which green facilities in their living neighborhoods are related to their mental health.

5.1. Conclusions

Use-frequency of green facilities

According to the literature, four mechanisms, including the direct exposure and other three intermediate mechanisms: physical activity, social ties and sense of community have been assumed to help explain the association between green facilities and mental health. However, the findings discovered in this research are not fully consistent with the hypotheses. As the empirical results show, the frequency that students visit green facilities in their neighborhoods has been suggested unable to directly determine students' mental health. Two literature derived intermediate mechanisms physical activity and social ties also turn out to have no capacity to mediate the relationship between the use-frequency of green facilities in the neighborhoods and mental health. Although students' use-frequency of green facilities in their neighborhoods can encourage them to spend more hours on performing activities like walking, cycling, and various types of sports, the hours that university students undertake physical activities have no influence on their mental health. One possible explanation could be that the intensity level of physical activities conducted were not taken into account. The effect of the activity intensity might not be linear but curvilinear. Paluska and Schwenk (2000) in their article pointed out the importance of intensity levels of physical activity in treating individuals' depression. Physical activity might need to be moderate enough to exert mental health benefits (Lee and Paffenbarger, 2000), but overtraining can also lead to some residual, significant depressive effects.

Conversely, university students' social ties appear to be beneficial for their mental health. However, surprisingly, in contrary to some previous studies, no association is found between students' social ties and their use-frequency of green facilities in their neighborhoods. This unexpected outcome might be due to the measurement of social ties. As a latent variable, because of the unidimensionality requirement social ties are indicated only by two indicators concerning social support, whereas most university students live in a rented student house (56.7%), rather than from neighbors and encounters, their social support is more likely to be acquired from their friends or families that might live outside of those students' neighborhoods.

Unlike the physical activity and social ties, sense of community as a potential intermediate mechanism derived from the literature has been confirmed to mediate the effect of students' use-frequency of green facilities in their neighborhoods on their mental health. Students who use green facilities in their neighborhood more often tend to feel more at home, feel having bonds with people in their neighborhoods, feel a sense of connection with their neighborhood, feel walking around the neighborhood pleasant and convenient and have a general higher sense of community perception towards their neighborhoods, thus positively contributing to a better mental health status. In addition, it has been proved in this study that university students' sense of community can be amplified by their social ties.

Even though, this study demonstrates a surprising finding that no significant direct, overall indirect and total effects of students' use-frequency of green facilities in their neighborhoods occur on their mental health. It confronts substantial empirical findings in general population showing that the use-frequency of green facilities is able to provide mental health benefits (e.g. Nielsen and Hansen, 2007).

Proportion of green facilities

Likewise, the empirical results of the analyses on the association between proportion of green facilities in the neighborhood and mental health presented in this report don't support the salutary effects of greenery on mental health. Although substantial evidence have suggested that the exposure to green settings serves physiological, emotional, and attentional restoration, this study has displayed no statistically significant direct association between the proportion of green facilities in students' neighborhoods and their mental health. Besides, this research examined the associations between greenness, physical activity, social ties, sense of community and mental health indices. It turns out that none of the three theoretical intermediate mechanisms plays a mediating role. The time that university students undertake physical activities is neither related to the proportions of green facilities in their neighborhoods nor their mental health indices. One potential explanation for the insignificant pathway from proportion of green facilities to physical activity may be that students don't rely on their neighborhoods for physical activities. They might turn to green facilities outside their neighborhoods (such as in the campus) or the gyms out of convenience and exercise equipment consideration.

For social ties and sense of community, in line with previous findings in general population, university students with stronger social ties are usually accompanied with higher sense of community towards their living neighborhoods. Although social ties and sense of community are both found to exert a significant influence upon mental health, no association has been discovered between the extent of greenness in the neighborhood and them. It could be because university students' social ties like their physical activity are not constrained inside the neighborhoods but extend to places like campus, bars, or gyms. The measurement of social ties could also play a role as the indicators can only represent the social support aspect of social ties. In addition, one potential factor explaining the unexpected result of no relationship between sense of community and proportion of green facilities in the neighborhood might be the quality

of greenness. Some types of green facilities like vacant lands with grass might account for a large proportion in the neighborhood but its low quality makes it less appealing for university students to use.

Overall, no direct, indirect, and total effects of the proportion of green facilities in the neighborhood which was defined as a buffer of 300m radius around the place of residence of every participant upon university students' mental health have been found in this study.

Demographic and socio-economic status

This study has also revealed interesting differences in students' mental health status, use of green facilities in their neighborhoods, physical activity, social ties, and sense of community among demographic and socio-economic variations. The empirical results highlight a higher use-frequency of green facilities and more positive mental health among male university students. Also, male students tend to facilitate their physical activity level through increasing the frequency they visit green facilities in their neighborhoods. However, things are different for social ties. Compared with female students, male students generally have a lower level of feeling of self-supported, they also tend to perceive people in their living neighborhoods as less concerned with and supportive to each other. Students' gender directly has no influence on their sense of community. Nevertheless, through indirectly affecting their use-frequency of green facilities and social ties, female students have a higher sense of community in terms of indirect effects. Additionally, in this study, students in a financial struggle tend to experience greater depression and anxiety. Other personal characteristics including students' age, nationality, education institution, housing situation, living duration, parental educational levels, students' smoking status and drinking status have been examined to exert no impact upon their mental health.

5.2. Theoretical implications

This study provides theoretical developments on the association between green facilities and mental health as well as the underlying mechanisms behind by giving insights into university students population. Previous studies regarding to green facilities and mental health focused primarily on general population or the elderly. This study puts an eye on university students who are considered as disproportionately affected by conditions such as depression and anxiety than other population groups. In contrary to a number of studies indicating that individuals who visit green facilities in the neighborhood more often tend to have a better mental health, surprisingly, this research reveals no association between university students' use-frequency of green facilities in the neighborhood and their mental health. The occurrence of such an outcome is perhaps because in such a special and complex life phase, university students are facing a lot of challenges and pressures from both academic study and society like changing identity and relationships (Blanco et al., 2008; Kadison, 2004) which make up of the sources of their mental disorders. Students' mental health status can fluctuate easily due to a coming exam or a coming deadline, for example. Therefore, compared with other more worrying influential factors of university students' mental health, the use of green facilities might not be able to exert an influence on their mental health condition. However, one intermediate mechanism—sense of community—through which university students' use of green facilities can positively influence their mental health is supported by the results of this study,

consistent with a deal of literature suggesting that green facilities play an important role in promoting residents' sense of community which in turn benefits mental health (e.g. Kim and Kaplan, 2004; De Silva et al., 2005). Nonetheless, it could also be the case that university students with better mental health status tend to have a better sense of community towards their neighborhoods.

The study doesn't find an association between the proportion of green facilities within 300m buffers around university students' living places and their symptoms of depression and anxiety. This is consistent with the finding by Nutsford et al. (2013) in New Zealand who discovered that the proportion of total and useable green space within 300m didn't exhibit significant associations on anxiety/mood disorder treatment counts. But it to a certain extent confronts with what Maas et al. (2009) found in the Netherlands, the proportion of green space within 1 km had a stronger correlation with anxiety and depression measures than the proportion within 3 km. The impossibility of detecting a significant association between university students' mental health and the access to green facilities within 300m buffer might result from the restriction of a lack of variance as there are less green facilities contained within the 300m buffer than 1km. The convenience extent of accessing neighborhood green facilities and the exclusion of private gardens in the green facility datasets might also take a responsibility for the no significant finding. Besides, compared with working-age individuals who are more likely to have settled down, the majority of university students are living in the same place for a relatively short period and are less likely to rely on the neighborhood, green facilities in immediate local neighborhoods may not be very important as long as they are within the acceptable vicinity.

5.3. Study limitation and future work

For this study, the data of the proportion of green facilities in the neighborhood were derived from two different land-use databases by different categories of greenness and the regression outcomes were compared. Consequently, there is no single source and classification bias. Also, this study combined the investigation of objective green environmental features and students' subjective use of greenery. Despite of the advantages in this study, some shortcomings are important to note. First of all, the green facilities datasets were derived from large-scale public scale data sources in which only green area has a dominant position are accounted as green area. The small-scale green facilities such as private gardens which might have the possibility to exert any positive influence on students' mental health were excluded. Therefore, a slight underestimate of the relation between neighborhood greenery and students' mental health might exist. Also, this study considered only the Euclidean distance buffer for the proportion of green facilities, the network distance which might influence students' accessibility to green facilities were not taken into account. Secondly, the measurement of physical activity only counted the students' active hours without taking the intensity of different activities into consideration. The intensity of physical activity was planned by referring to SQUASH (The Short Questionnaire to Assess Health-Enhancing Physical Activity) at the first place in the questionnaire of this study, but most of the participants tended to not answer it. The place that students undertake physical activities were also not clarified. Students might probably conduct physical activity elsewhere like gyms to compensate the lack of green facilities in the neighborhood.

The third limitation is the measurement of university students' social ties. It can only represent the social support aspect as the social contacts of students with neighbors or their friends were removed due to the unreliability of data acquired from survey. In addition, this study limited mental health to the presence of symptoms of depression and anxiety rather than to look at broader definitions of mental well-being, which might show a different association with green facilities in the neighborhood. Moreover, although several random selection procedures have been used in this research to ensure the representativeness of the research sample, some university students who are in a bad mental condition may be excluded from the recruitment as they might stay at home and don't show up in the library or in the campus hence cannot be reached.

By exploring the association of green facilities and mental health among university students in Utrecht, this study provides some guidelines for future studies. First, a need for a more detailed dataset which can represent smaller and localized green facility features was identified. Future studies should further investigate the potential influence of personal green space like individual gardens on mental health. In addition, future studies can integrate the network distance access to green facilities into the investigation of the amount of greenness in the neighborhood, exploring not only the amount of green facilities in the buffer but also the accessibility to greenery (such as the time it takes for one to walk to the nearest green place). An improvement of the measurement of social ties is needed to acquire reliable social interaction data, and the intensity level of physical activity undertook should be taken into account in data collection of future research. Besides, this study looked only at the university students, further research could extend research objects to other young people and use other scales, such as Satisfaction with Life Scale (SWLS) (Diener et al., 1985), or the Scale of Positive And Negative Experience (SPANE) (Diener et al., 2010), to examine not only mental illness but a broader definition of mental well-being. Furthermore, a qualitative approach can be applied in future research to give depth insights into university students' mental health status and their personal experiences of green facilities in the neighborhood, and to figure out the reasons why no association were found between green facilities and their mental health as well as what other factors play a role. Lastly, future work can explore the association between their study environment and mental health as university students tend to spend a great deal of time in the university.

5.4. Policy implications

There are several policy implications arising from this research. Although this study shows no relationship between the proportion of green facilities in university students' neighborhoods and their mental health, sense of community has been found to mediate the mental health benefit of students' use-frequency of green facilities. Policies concerning green provision do not exclusively benefit university students. To promote university students' mental health by enhancing environment, the urban planning and design strategies need to place emphasis on the importance of sense of community and increasing the attractiveness of green facilities in the neighborhood (such as increasing more sport facilities like basketball courts, or increasing the diversity of greenery in the neighborhood) to encourage the utilization.

Besides, the empirical results suggest that university students' mental health largely rely on their social aspects such as social ties and sense of community. Accordingly, social ties and sense of community and their connection to university students' mental health have important implications for health policy. The government could initiate public awareness campaigns on the value of positive social relationships and educational or counselling services in universities to promote the benefits of social ties among universities. Also, policies can diminish the risk of social isolation in the first place by improving educational systems on providing social and emotional skills and increasing civic engagement. Not only the government but also some local organizations as well as universities can play a role in promoting more interactions between university students. Public health organizations can coordinate with universities to enhance university students' understanding of the mental health benefits of social interactions through giving speeches, lectures or organizing workshops. Also, they can help universities to identify socially isolated students, using local resources to offer social, emotional, and instrumental support to these students.

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Questionnaire

Dear respondent,

My name is Zheyan Chen. I'm a master student in Human Geography and Planning at Utrecht University. I'm doing a research on examining the influence of green facilities on university students' mental health.

Thank you for agreeing to take this survey. The purpose of the survey is to collect experiences from university students about the green facilities in their neighborhoods.

All of the answers you provide in this survey will be kept confidential. The survey data will be reported in a summary fashion only and will not identify any individual person. Please answer every question honestly and keep in mind that there is no right or wrong answer.

This survey will take about 10-15 minutes to complete.

Basic information

Q1. Age: _____

Q2. Gender: ☐ Female   ☐ Male

Q3. Nationality: _____

Q4. Where do you live now?   Postal number*: _____ City: _____
*(*This is important. Because I'm studying the green facilities in your neighborhood, I need to visualize them on the digital map. You don't have to provide your house number, but please fill in the postal code. Thank you for your understanding)*

Q5. What is your current education institution?
    ☐ Utrecht University   ☐ HU University of Applied Sciences Utrecht
    ☐ Other, please specify _____

Q6. Which department are you in? _____

Q7. When did you start your study in your university? _____ year _____ month

Q8. What is your university enrolment status?

☐ part-time   ☐ full-time

Q9. What is your housing situation now?
- ❑ Live in a student house with other students
- ❑ Live in an individually rented room in an apartment or a house
- ❑ Live with a partner
- ❑ Live individually in a studio or an apartment
- ❑ Live with parents
- ❑ Other, please specify _____

Q10. How long have you been living in your current neighborhood? _____year(s)_____month(s)

Q11. Which describes your parental education level:
- Mother: ☐ elementary school or less   ☐ secondary school   ☐ higher vocational education
            ☐ academic education   ☐ unknown
- Father: ☐ elementary school or less   ☐ secondary school   ☐ higher vocational education
            ☐ academic education   ☐ unknown

Q12. What is your current financial situation?
- ❑ It's a financial struggle
- ❑ It's tight but I'm doing fine
- ❑ Finances aren't really a problem

Q14. How many cigarettes do you smoke now per week on average?

☐ None   ☐ 1-7 per week   ☐ 8-14 per week   ☐ 15-21 per week

☐ 22-28 per week   ☐ 29-35 per week   ☐ 36-42 per week   ☐ 43 or more per week

Q15. How many drinks (a drink is defined as: a bottle of beer, a glass of wine, or a shot of liquor straight or in a mixed drink) do you usually have per week?

☐ None   ☐ 1-4 per week   ☐ 5-8 per week   ☐ 9-12 per week

☐ 13-16 per week   ☐ 17-20 per week   ☐ 21-24 per week   ☐ 25 or more per week

Mental health

Think about the past seven days including today. Please indicate how you have felt during that period.

Items	Not at all	Slightly	Pretty much	Extremely
1. Suddenly scared for no apparent reason				

Items	Not at all	Slightly	Pretty much	Extremely
2. Feeling fearful				
3. Faintness, dizziness, or weakness				
4. Feeling tense or keyed up				
5. Blaming yourself for things				
6. Difficulty in falling asleep or staying asleep				
7. Feeling blue/sad				
8. Feeling of worthlessness				
9. Feeling like everything is an effort				
10. Feeling hopeless about the future				

Green facilities in your neighborhood

Please read the following questions and fill in the numbers carefully. They need to be answered respectively according to the following three types of green facilities: *I.urban park; II. forest or nature areas; III. green sports facilities (e.g. stadiums, basketball field with green trees)*. Please write down '\' if you don't have that type of green facilities **in your neighborhood**.

	Urban park	Forest or nature areas	Green sports facilities
Q1. How often do you use these types of green facilities in your neighborhood? (times per week)			
Q2. How long on average do you usually spend in these green facilities in your neighborhood each time? (hours per time)			
Q3. How often do you go to these green facilities in your neighborhood alone? (times per week)			
Q4. How often do you go to these green facilities in your neighborhood with your friends, family members or neighbors? (times per week)			
Q5. How often do you wave, say hello, or stop and talk with people you encounter in these green facilities in your neighborhood? (times per week)			

Q6. Which park(s) do you visit <u>in your neighborhood</u> (if any)?

_____

_____

Q7. Which park do you most often visit <u>outside your neighborhood (if any)</u>?

_____

Friends and social support

Q1. How often do you wave, say hello, or stop and talk with people you encounter in your neighborhood on average? (times per week)

_____

Q2. How many friends (including friends in your house or your neighborhood) do you have regular contact with?

_____

Q3. How often do you meet (do joint activities) with friends in general? (times per week)

_____

Q4. How often do you have contact with your neighbors? (times per month)

_____

	Not at all	slightly	moderately	very	extremely
Q5. How socially supported (including: emotional support with problems, instrumental interactions and informative support) do you feel <u>by your direct physical and social environment?</u>					
Q6. Are people around your living place concerned with helping and supporting one another?					

Physical activity

Q1. Think about an average week in the past months. Please indicate how many days per week you performed the following activities, how much time on average you were engaged in this (on days when you did these activities), and (if applicable) how strenuous this activity was for you?

Activities	days	average time	effort
	Days per week	*Hours per active day*	*(please circle)*
Walking			slow/moderate/fast
Running			slow/moderate/fast
Cycling			slow/moderate/fast
Sports (please write down yourself) e.g. basketball, tennis, swimming, indoor training			
1.			light/moderate/intense
2.			light/moderate/intense

Q2. Think about an average week in the past months. Please indicate respectively how many hours per week you performed the following activities **in the aforementioned three types of green facilities in your neighborhood** *(I.urban park; II. forest or nature areas; III. green sports facilities (e.g. stadiums, basketball field with green trees))*. Please write down '\' if you don't have that type of green facilities in your neighborhood.

Activities	Duration		
	*Hours **per week***		
	Urban park	*Forest or nature areas*	*Green sports facilities*
Walking			
Running			
Cycling			
Sports (please write down yourself) e.g. basketball, tennis, swimming			
1.			
2.			

Sense of community

Please indicate how you feel about the neighborhood you live in.

	strongly disagree	disagree	neutral	agree	strongly agree

1. I feel at home in my neighborhood					
2. I feel I have bonds with people in my neighborhood					
3. I feel a sense of connection with my neighborhood					
4. I feel walking around the neighborhood is pleasant and convenient					
5. Living in my neighborhood gives me a sense of community					

Suggestions

Thank you very much for taking the time to complete the survey. Please write down your suggestions if there is anything I should improve in the survey to make the questions easier to understand.

_____

_____

_____

_____

If you have questions about your rights as a participant in this survey, or are dissatisfied at any time with any aspect of the survey, you may contact me by email at z.chen2@students.uu.nl.