Utrecht University

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MSc Social Policy & Public Health

Master Thesis

Cumulative Greenspace Exposure on Young Adult's Mental Health and Socioeconomic Status Moderators

Studying the association of greenspace exposures on young adults' mental health and the effects of socioeconomic status during childhood and adulthood as moderators of mental health: findings from the PIAMA study

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Abstract

The environmental context in which a person lives serves as a background factor that can trigger, reduce, or amplify the risk of suffering from a mental disorder. Poor mental health in young people can lead to further health concerns like lower educational achievements, substance abuse, and poor reproductive and sexual health. With more urbanisation on the rise, there is less access to greenspaces. This serves as a problem when there is increasing research stating that natural environments, like greenspaces, highly benefit a person's mental wellbeing. This research examines how proximity to greenspace during adolescence affects the mental health of young adults. Moreover, we will be studying how socioeconomic status (SES) acts as a moderator for mental health as the individual moves from their family SES at age 11 to their own SES at age 17 or 20. We found that more exposure to green vegetation is important to the mental well-being of individuals. There was no moderating factor between childhood greenspace exposure and young adult mental health across any level of SES–both parental and adolescence SES. Regardless of the results from this analysis, greenspace still remains important to the well-being of individuals, society and our planet. We should still continue to create policies and interventions toward preserving greenspaces amid urbanisation.

Key words: Greenspace, Socioeconomic status, Mental Health, Adolescence

Effects of Greenspace on Young Adult's Mental Health and Socioeconomic Status Moderators During Adolescence to Adulthood

Mental illness is among the most significant public health challenges worldwide (WHO, 2015). There is a greater risk and vulnerability to mental illnesses for disadvantaged people due to challenges like financial insecurity, rapid social change, risks of violence, and physical ill-health (WHO, 2004). For adolescents, mental illnesses can range from anxiety disorders (e.g. social anxiety, panic attacks, obsessive-compulsive disorder) to mood disorders (e.g. bipolar disorder, major depressive order) and attention deficit hyperactivity disorder (ADHD) or disruptive behaviour disorders (ACOG, 2017).

Studies suggest that most mental health problems begin during adolescence (12-24 years of age) and can have long-lasting effects even after childhood (Patel et al., 2007). From a public health perspective, poor mental health in young people is strongly correlated with developmental concerns like lower educational achievements, substance abuse, violence, and poor reproductive and sexual health (Patel et al., 2007). Since mental health affects multiple aspects of a person's health and wellbeing throughout their lives, researchers must focus on adolescent risk and protective factors. On an individual level, characteristics like genetic factors, demographic characteristics (i.e. age, gender, ethnicity, race, etc.), socioeconomic conditions (i.e. education level, income, etc.), and traumatic experiences can all influence mental health problems (Belsky et al., 2019; Helbich, 2018; Lorant et al., 2003; Rosenfield & Smith, 2012; Van Dyck et al., 2015). However, these individual characteristics are not the only influencing factors (Kestens et al., 2017).

According to the socioecological model of health (Sallis et al., 2008), there are multiple levels of influences that interact with one another to shape people's health behaviours. The socio-environmental context in which a person lives serves as a background factor that can trigger, reduce, or amplify the risk of suffering from a mental disorder (Helbich, 2018). There is increasing evidence that natural environments (i.e., greenspace) might be a determinant of mental health, suggesting that greenness reduces stress and has restorative effects on people's wellbeing (Helbich, 2018). Therefore, this research will examine how proximity to greenspace during adolescence affects the mental health of young adults as they transition from adolescence. Moreover, we will be studying how socioeconomic status (SES) acts as a moderator for mental health as the individual moves from their family SES (age 11) to their own SES (age 17/20).

Neighbourhood Environments on Mental Health

In recent years, there has been a prominent focus on studying how physical and social aspects of a person's neighbourhood affect mental health. Physical aspects of a neighbourhood can include both natural or built environments (e.g. urban cities with greenspace available). With more urban cities on the rise, many studies have focused on the association of long-term exposure to surrounding green (or lack thereof), air pollution, or traffic noise and its link to poor mental health (Klompmaker et al., 2019). Researchers found that people reported a reduced risk of poor mental health with increasing surrounding greenspace (Triguero-Mas et al., 2015; Sugiyama et al., 2008). For adolescents, studies show greenspace exposure correlates with fewer emotional and behavioural difficulties, specifically hyperactivity and inattention problems (Vanaken & Danckaerts, 2018). There is limited evidence suggesting a beneficial association between greenspace exposure and the mental well-being of adolescents and young adults in general; however, there is strong evidence that adolescents with ADHD suffer from other emotional and psychiatric disorders unrelated to ADHD, even into adulthood (Barbaresi et al., 2013; Biederman et al., 1996; Strine et al., 2006).

Though existing literature lacks a consistent operational definition of "greenspace", we define it as all forms of natural environments ranging from areas of vegetation, like food crops, forests, or wilderness areas to parks, gardens, or backyards (Taylor and Hochuli, 2017). 55% of the world's population currently lives in urban areas, with projections showing an increase of 2.5 billion people to these cities by 2050 (United Nations, 2018). Specifically in Europe, over 70% of people live in urban areas (United Nations, 2015). Given this prevalence of urban city dwellers, greenspaces remain a viable contributing factor toward individuals' quality of life. The World Health Organization (2017) reviewed the impacts and effectiveness of urban greenspace interventions and found that providing more greenspaces helps promote active lifestyles, positive equity, and social cohesion, all of which improve mental health (Bedimo-Rung et al., 2005; Hartig et al., 2014). Making greenspaces more accessible in the cities is even included in the United Nations Sustainable Development Goal 11.7.

Greenspace Exposure to Adolescent Mental Health

Reducing exposure to air pollution and noise traffic

Previous studies describe at least three pathways through which greenspace can improve adolescent mental health and well-being (Markevych et al., 2017). The first pathway focuses on how greenspace influences mental health by reducing harm to the individual. Typically, traffic-related air pollutants and noise pollution are lower in urban greenspaces because of the lack of traffic in these areas (Su et al., 2011). Noise exposure leads to annoyance and sleep disturbance and causes daytime sleepiness which contributes to further mental health concerns, specifically in cognitive performance, like hyperactivity in schoolchildren (Basner et al., 2014). In a national health survey in the Netherlands, researchers found that air pollution was positively correlated with poor mental health (Klompmaker et al., 2019).

Stress reduction

The second pathway associating greenspace environments with mental health is psychological restoration or stress reduction (Mears et al., 2020; Markevych et al., 2017). Extensive research has focused on the health benefits of nature interactions. In a Dutch study, researchers found that residents living in neighbourhoods with more streetscape greenery perceived their health as better (i.e., experienced less acute health-related complaints and better mental health status than residents living in neighbourhoods with less streetscape greenery) (Gubbels et al., 2016). This evidence links to the stress reduction theory (Ulrich et al., 1991), which suggests that exposure to green helps mitigate the psychological stress of everyday societal demands. Studies suggest that introverted adolescents, specifically girls, tend to experience poorer mental health. In the Netherlands, there is evidence that residential exposure to greenspace is associated with lower stress levels in children 12 years of age (Bloemsma et al., 2021).

Encouraging physical activity and social cohesion

Greenspaces can encourage physical activity, which provides physical, psychological, and mental health benefits (Mears et al., 2020; Markevych et al., 2017). Studies in several countries showed that recreational walking (i.e., increased physical activity and reduced sedentary time) was associated with access to and use of greenspaces in working-age adults, children, and senior citizens (WHO, 2016). Providing attractive and available urban greenspace may encourage people to spend time outdoors and facilitate physical activity (Bedimo-Rung et al., 2005), especially since physical activity helps improve mental health through neurocognitive development and general well-being (Owen et al., 2010). Greenspace not only provides a safe, accessible, and attractive setting in which to conduct physical activities, but it also provides a setting for increased social contact and social cohesion among neighbours (Markevych et al., 2017). Social cohesion is defined as a sense of community, focusing on trust, shared norms and values, positive and friendly relationships, and feelings of being accepted and belonging (Forrest et al., 2001). In a Dutch study, researchers found that less greenspace in people's living environments coincided with feelings of loneliness and a perceived shortage of social support (Maas et al., 2009; WHO, 2016).

Socioeconomic Status (SES) Inequalities in Mental Health and Greenspace

Evidence shows that providing greenspace access could potentially reduce mental health inequalities associated with socioeconomic deprivation (Maas et al., 2009). Extensive literature posits that two competing hypotheses explain the relationship between socioeconomic status and mental illness. The social causation hypothesis asserts that those experiencing economic hardships have an increased risk of subsequent mental illness (Hudson, 2005). While the selection/drift hypothesis posits that mental illness can inhibit socioeconomic attainment and lead people to drift into lower social class or never escape poverty (Mossakowski, 2014). We know that adolescents living with lower SES parents are susceptible to becoming lower SES adults, indicating a vicious cycle of adolescents growing up in low SES conditions which links to bad mental health, leading to more intergenerational disadvantages (Cheng et al., 2016). A longitudinal study in New York indicated that low family SES associates with offspring anxiety, depression, disruption, and personality disorders (Johnson et al., 1999). Therefore, when looking at health equity at a population level studies suggest that promoting the availability of, and use of, greenspace by young families in low-income areas may be effective in improving mental health outcomes (Cronin-de-Chavez et al., 2019).

Low-income groups experience different barriers when trying to access urban greenspaces. For instance, areas with more social and economic deprivation indicators may have less access or lower quality greenspace (Rigolon, 2016). Sugiyama et al. (2008) found that residents living in lower SES areas were significantly more likely to have higher psychological distress than those in higher SES areas. Moreover, when looking into park quality, participants in the highest SES areas had more land allocated to parks than those in relatively lower SES areas. In a literature review, Barakat & Yousufzai (2020) focused on the relationship between mental health and greenspace in relation to issues of accessibility and inequity among vulnerable populations. They concluded that greenspace is a key feature of urban environments at the neighbourhood scale for vulnerable populations as they provide a psychologically restoring space for positive social activity and behaviour. Reducing socioeconomic inequalities and providing interventions for families with low parental education can help reduce children's mental health problems and potentially improve their SES in the future (Miech et al., 1999).

Present Study

This research will focus on how proximity to greenspace during adolescence affects young adults' mental health. The first research question asks, does cumulative exposure to greenspace from ages 11-20 predict young adults' mental health at age 23? Our follow-up research question examines if this effect is moderated by their childhood SES (i.e. their parents' SES) or by their own SES at age 17/20?

We hypothesise that more exposure to greenspace predicts higher mental health in young adults. In regards to SES, we hypothesise that the SES is a moderating factor towards increased mental health with respect to greenspace exposure. For participants with low parental or low adolescent SES, we predict that greenspace plays a more impactful role on mental health.

Methods

Study design and population

The data utilised comes from the ongoing Dutch Prevention and Incidence of Asthma and Mite Allergy (PIAMA) birth cohort study (Brunekreef et.al., 2002). The detailed design and use of the PIAMA birth cohort study have been described in former publications (see Bloemsma et al. 2018, 2021, 2022). This study recruited pregnant women from the general population of the Netherlands. Researchers focused on 3 regions, the north (provinces of Friesland, Groningen, and Drenthe), the central (provinces of Utrecht, Gelderland, and Flevoland), and the west (Rotterdam and surrounding municipalities). Levels of greenspace are the highest in the Northern region and the lowest in the Western region.

The children (*N*=3,963), born in 1996/1997, have been followed from birth onwards. Data was collected across several waves, including yearly from 1 to 8 years, where the parents completed the questionnaires, and at ages 11 and 23, when the children themselves completed separate questionnaires. The questionnaires covered questions regarding growth and development, demographics and parental/adolescent characteristics, education, lifestyle, and environmental exposures.

This study protocol was approved by the medical ethical committees of the participating institutions and all parents and adolescents gave written and informed consent for participating. In this study, 1349 adolescents (34.04% of the baseline study population) were used in the data analysis as those were the number of participants with complete greenspace exposure scores at 11, 14, 17, and 20.

Measures

Greenspace exposure

This analysis uses existing methods to estimate greenspace exposure, measured between the ages of 11 to age 20 (Bloemsma et al. 2018, 2021, 2022). Participants' addresses (measured at each time point) were linked to geographic data on greenspaces (for further details see Bloemsma et al. 2018, 2021,2022). Scores from ages 11, 14, 17, and 20 were averaged to produce a cumulative exposure to the greenspace measure during adolescence. Researchers use two indicators to calculate greenspace proximity: Normalised Difference Vegetation Index (NDVI) and Bestand Bodemgebruik/ TOP10NL.

Green Vegetation Density Index. The NDVI used Landsat 5 Thematic Mapper data to determine the density of green vegetation, like plants, scrubs, and trees within buffers of 3000m. These values range from -1 to 1 with higher values indicating a higher density of green vegetation.

Total Greenspace Percentage. Bestand Bodemgebruik/ TOP10NL are detailed land-use maps of the Netherlands. This indicator was used to estimate the total percentage of greenspace (i.e percentage of urban, agricultural and natural greenspaces combined) at buffer levels of 3000m. Land-use maps did not include street greenery or private green property.

Controlled Variables

Adolescent mental health problems differ by gender (Campbell et al., 2021), therefore we controlled for it. Gender was measured by asking if the participant was a girl (coded 0) or a boy (coded 1). There was one participant that answered transgender. Ultimately, we had to remove them from the sample as the data would not be meaningfully analysed with only one participant in the category.

Socioeconomic Status Exposure

Family SES. Family SES will be based on the paternal and maternal education level obtained by the mother and the father when their child was roughly 1 year old. The education level was categorised as 1 = low (primary school, lower vocational, or lower secondary education), 2 = medium (intermediate vocational education or intermediate/higher secondary education), or 3 = high (higher vocational education and university). In the Netherlands, education level correlates strongly with indicators of SES (De Graaf et al., 2000). For this study, we measured parental SES by taking the lower education level of the parents. As this sample is disproportionately high SES, we coded our sample in this way to ensure more variance in the SES construct. Individuals of lower SES are less likely to participate in health surveys than individuals of higher SES which can lead to test sampling bias (Lorant et al., 2007; Fakkel et al., 2020).

Adolescent SES. Adolescent SES will be based on the highest education level obtained by the participants at either age 17 or 20, depending on what was available. These responses will be coded as the same as the parent SES levels.

Mental Wellbeing

From the dataset, at ages 11 to 23, participants of the PIAMA study were requested to complete the Mental Health Inventory-5 (MHI-5) (Rumpf et al., 2001; Berwick et al., 1991). MHI-5 is an international standard for psychological health that uses five questions to assess mental wellbeing. It concerns questions that relate to how people have felt in the past 4 weeks, and it asks 1) did you feel nervous?; 2) were you so down that nothing could cheer you up?; 3) did you feel calm and peaceful?; 4) did you feel depressed and gloomy?; and 5) did you feel happy? Each question has the following 5 Likert scale answer categories: “all the time, mostly, often, sometimes, never". For the positively formulated questions (questions 3 & 5), the values 5, 4, 3, 2, and 1 were assigned in that order. For the negatively formulated questions (questions 1, 2, & 4), exactly the opposite values (1, 2, 3, 4, & 5) were assigned. For the analysis, questions 3 & 5 were recoded in order to provide an accurate MHI-5 score.

The MHI-5 score was calculated by adding the sum scores together subtracting by 5 and then multiplying by 5 so that the minimum sum score of a person can be 0 (very unhealthy) and the maximum score 100 (perfectly healthy). According to the MHI-5 standard, for those with a score of 60 or more, the respondent is qualified as psychologically healthy and those with a score of less than 60 are psychologically unhealthy (Berwick et al., 1991). For this study, we will keep this standard in mind in assessing and defining their mental state, but we will ultimately be treating the MHI-5 score as a continuous measure.

Data Analysis

For this current study, statistical analyses were done with IBM SPSS Statistics. Participants that did not complete the questionnaire at ages 11, 14, 17, 20, and 23 were excluded from further analysis. Additionally, we only included those in which we had both parents' highest level of education from the data. In this study, a p-value of <.05 was used for significance testing. Pearson correlation was used to characterise the correlations between greenspace indicators, mental health, socioeconomic status, and gender.

In order to test the effects of greenspace and SES on mental health, regression analyses were done. Moreover, as there are two greenspace variables (green vegetation density and total greenspace percentage), we ran two separate analyses for each model. The first linear regression models include the effects of greenspace variables and gendered control on mental health at age 23.

For the next analysis, we ran two sets of regression models, subsection by adolescent SES and parent SES, respectively. In the first model, the data was divided by adolescent SES– low, medium and high. By subdividing the data, we are able to compare the association of greenspace variables on mental health at each adolescent SES level. Then, to the same model, we added parental SES as a predictor. Using dummy variables–low and high, with reference to medium level, we are able to see how parental SES and greenspace associate with young adults' mental health when the data is divided by adolescent SES.

Finally, to examine the association of parental SES on greenspace and mental health, we followed the same steps as the previous model but we split the data by parental SES–low, medium and high. This allows us to compare the association of greenspace variables with mental health at each parental SES level. Then, we added adolescent SES dummy variables as a predictor. With this model, we can examine the association of the adolescent's SES and greenspace on mental health at the different parent SES levels.

Results

Descriptive statistics

Descriptive statistics of categorical variables (gender, adolescent SES and parent SES) are described in Table 1. Of the participants, 60.4% had at least one parent with higher vocational education or university (category 3), while only 8.3% of participants had both parents with lower vocational or lower secondary education (category 1). Most participants (>75%) had parents with either intermediate vocational education or higher vocational education and university indicating that most participants lived in a medium to high SES environment. The same goes for adolescent SES, where 77.2% had medium or high education levels. Between the ages of 11 and 20, the participants lived in moderately urban environments, though on average they had 20-50% of agricultural, urban, and natural greenspaces within buffers 3000m of their homes. Similarly, participants had 20-70% of green vegetation within their homes.

Table 2 shows a strong correlation between green vegetation density at 3000m and the total percentage of greenspace (agricultural, urban and natural) at 3000m ($r = 0.83$). In regards to mental health, the greenspace variables had a weak, positive correlation to mental health at age 23 (Green vegetation: $r = 0.06$, Total greenspace: $r = 0.06$). Males, when compared to females, predict higher mental health ($r = 0.15$). Compared to their medium adolescent SES counterparts, adolescents with high SES are linked to lower mental health ($r = -0.06$).

When looking at correlations between SES and greenspace variables, we see some discrepancies between the green vegetation and total greenspace. For adolescent SES compared to green vegetation, we see that having high SES negatively correlates to both greenspace variables when compared to medium SES (Green vegetation: $r = - 0.06$, Total greenspace: $r = -0.11$).

Table 1

Descriptive statistics of gender and education level

Variables:		**N**	**%**
Total		1349	100
Young Adult Gender			
	Female	787	58.3
	Male	562	41.7
Adolescent SES at Age 17/20			
	Low	308	22.8
	Medium	572	42.4
	High	469	34.8
Parental SES			
	Low	362	26.8
	Medium	534	39.6
	High	453	33.6

N= Sample Participants

Table 2

Descriptive and correlations of mental health, greenspace, SES, air pollution, and degree of urbanisation

Variables:	**Mean**	**SD**	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Mental Health Age 23 **(1)**	63.90	19.31	-							
Green Vegetation Density Index **(2)**	0.60	0.09	0.06*	-						
Total Greenspace Percentage (**3**)	52.59	17.09	0.06*	0.83*	-					
Low Parental SES ~ **(4)**		0.44	0.01	-0.01	0.07*	-				
High Parental SES ~ **(5)**		0.47	-0.03	-0.04	-0.11**	-0.43**	-			
Low Adolescent SES ~ **(6)**		0.42	0.02	0.06*	0.11**	0.26**	-0.26**	-		
High Adolescent SES **~ (7)**		0.48	-0.06*	-0.11*	-0.17**	-0.27**	0.33**	-0.40**	-	
Gender ^ **(8)**		0.49	0.15**	0.05	0.05	-0.05	0.04	0.04	-0.05	-

**p* < .05, ***p* < .01, ****p* < .001,*

~ Reference group Medium Parental SES and Young Adult SES respectively,

^ Reference group Girl

For total greenspace, in comparison to medium SES, high parental SES (r = -0.11) and high adolescent SES (r = -0.11) negatively correlated to total greenspace percentage at 3000 m buffers.The opposite, positive correlations happen with low parental SES (r = 0.07) and low adolescent SES (r = 0.11) with total greenspace. Low parental SES, compared to medium parental SES, positively correlates with low adolescent SES (r = 0.26).

Linear Regression Analysis

The first linear regression model (Table 3) showed that after adjusting for gender, more green vegetation is associated with better mental health at age 23 (B = 12.73, p = 0.036). There was no significant relationship between total greenspace and mental health.

Table 3

Regression models showing the effects of Green Vegetation (A) and Total Greenspace (B) on Mental Health at age 23

			Model 1A	
Predictor	**B**	**β**	***P***	**CI 95%**
Intercept	48.14		<.001	[40.43,55.85]
Green Vegetation Density Index	12.73	0.06	0.036	[.83,24.63]
Gender	5.71	0.15	<.001	[3.64,7.79]
R Square			0.03	
			Model 1B	
Predictor	**B**	**β**	***P***	**CI 95%**
Intercept	52.84		<.001	[48.56,57.21]
Total Greenspace Percentage	0.06	0.05	0.073	[-.005,.12]
Gender	5.75	0.15	<.001	[3.67,7.82]
R Square			0.03	

B= Unstandardized Beta, β=Standardized Beta, P=Significance, CI= Confidence Interval

In the next linear regression models (Table 4), we ran analyses with the data subsection by adolescent SES low, medium and high. By analysing the data in each subsection, we see the association between greenspace variables and the three levels of adolescent SES. There were no significant results within these models. Even after running the analysis with parental dummy variables, we saw no significant results.

Table 4

Regression models showing the effects of Green Vegetation (A) and Total Greenspace (B) on Mental Health at age 23 with the data sub sectioned by Adolescent SES- Low, Medium & High

		Model 2A			
Adolescent SES	**Predictor**	**B**	**β**	***P***	**CI 95%**
Low	**Green Vegetation Density Index**	10.14	0.05	0.400	[-13.53,33.80]
	R Squared			0.002	
Medium	**Green Vegetation Density Index**	15.61	0.07	0.116	[-3.84,35.05]
	R Squared			0.004	
High	**Green Vegetation Density Index**	12.91	0.06	0.216	[-7.56,33.38]
	R Squared			0.003	
		Model 2A			
Adolescent SES	**Predictor**	**B**	**β**	***P***	**CI 95%**
Low	**Total Greenspace Percentage**	0.07	0.06	0.277	[-0.06,.19]
	R Squared			0.004	
Medium	**Total Greenspace Percentage**	0.05	0.04	0.370	[-0.05,.14]
	R Squared			0.001	
High	**Total Greenspace Percentage**	0.05	0.05	0.304	[-0.05,.16]
	R Squared			0.002	

B= Unstandardized Beta, β=Standardised Beta, P=Significance, CI= Confidence Interval

Table 5

Regression models showing the effects of Green Vegetation (A) and Total Greenspace (B) on Mental Health at age 23 with data sub sectioned by Parent SES- Low, Medium, and High (Model 3A & 3B). Model 4A & 4B is the effect of Adolescent SES- Low and High with reference to Medium.

		Model 3A				Model 4A			
Parent SES	**Predictor**	**B**	**β**	***P***	**CI 95%**	**B**	**β**	***P***	**CI 95%**
Low	**Green Vegetation Density Index**	10.40	0.05	0.315	[-9.91,30.73]	9.48	0.05	0.363	[-10.98,29.94]
	Low Adolescence SES					0.08	0.002	0.972	[-4.33,4.49]
	High Adolescent SES					-2.78	-0.05	0.384	[-9.06,3.50]
	R Squared			0.003				0.005	
Medium	**Green Vegetation Density Index**	21.40	0.09	0.045	[.52,42.27]	20.26	0.08	0.059	[-0.78,41.30]
	Low Adolescence SES					0.31	0.007	0.884	[-3.84,4.46]
	High Adolescent SES					-1.58	-0.04	0.421	[-5.42,2.27]
	R Squared			0.008				0.009	
High	**Green Vegetation Density Index**	10.32	0.04	0.350	[-11.34,31.99]	10.34	0.04	0.352	[-11.47,32.15]
	Low Adolescence SES					-4.41	-0.06	0.229	[-11.59,2.78]
	High Adolescent SES					-2.23	-0.06	0.247	[-6.01,1.55]
	R Squared			0.002				0.007	

		Model 3B				Model 4B			
Parent SES	**Predictor**	**B**	**β**	***P***	**CI 95%**	**B**	**β**	***P***	**CI 95%**
Low	**Total Greenspace %**	0.05	0.05	0.375	[-0.06,.16]	0.04	0.04	0.450	[-0.07,.15]
	Low Adolescence SES					0.09	0.002	0.969	[-4.32,4.50]
	High Adolescent SES					-2.73	-0.05	0.394	[-9.04,3.57]
	R Squared			0.002				0.005	
Medium	**Total Greenspace %**	0.07	0.06	0.188	[-0.03,.17]	0.06	0.05	0.249	[-0.04,.163]
	Low Adolescence SES					0.23	0.005	0.913	[-3.94,4.41]
	High Adolescent SES					-1.68	-0.04	0.393	[-5.56,2.19]
	R Squared			0.003				0.005	
High	**Total Greenspace %**	0.06	0.05	0.261	[-0.05,.17]	0.06	0.05	0.293	[-0.05,.17]
	Low Adolescence SES					-3.70	-0.05	0.305	[-10.78,3.38]
	High Adolescent SES					-2.80	-0.06	0.238	[-6.07,1.51]
	R Squared			0.003				0.007	

B= Unstandardized Beta, β=Standardised Beta, P=Significance, CI= Confidence Interval

In the last set of linear regression models (Table 5), we analysed the greenspace variables with the data subsection by parental SES low, medium and high. In the first model (3A), we saw that more green vegetation density within 3000 m buffers is associated with better mental health for participants with medium parent SES (B = 21.40, p = 0.045). Low and high parent SES showed no significant values. However, when looking at the results for medium parent SES, we see that the confidence intervals fall 0.52 over 0 and the unstandardized beta is just within the confidence intervals for low and high. Therefore, this association between medium parent SES and green vegetation on mental health at age 23 might not be significant.

As shown in Model 3B, total greenspace showed no significant correlation with mental health. Even after adding adolescent SES (low and high, in reference to medium), we saw no significant results predicting mental health at age 23 (Model 4A & 4B).

Discussion

With increasing urban developments, many researchers are focusing on the association between greenspace exposure and mental health. The results of this present analysis indicate that greenspace exposure during childhood predicts higher mental health in young adults, specifically in areas with high green vegetation density. Therefore, more exposure to green vegetation is important to the mental well-being of individuals. Moreover, there is increasing interest in how individuals of different SES levels can benefit from greenspace exposure, indicating that greenspaces can be a moderating factor for increased mental well-being of individuals with low SES. In this analysis, there was no moderating factor between childhood greenspace exposure and young adult mental health across any level of SES–both parental and adolescence SES.

Our findings are in line with the previous PIAMA research, where a higher density of green vegetation within buffers of 3000 m is associated with better mental wellbeing at age 11 to

20 (Bloemsma et al., 2022). However, Bloemsma et al.(2022) research also found that the total percentage of greenspaces at buffers of 3000 m was also associated with better mental health, a result that was insignificant in our study. Reasons for contrasting results could be because our present study uses the participant's mental wellbeing at age 23, which falls outside of adolescence years (age 10-19)(WHO, 2005). At age 23, participants are emerging adults, with changing experiences from ending their educational career, to early stages of their employment careers, sexually maturity, and other socio-confluences that could potentially affect their mental health (Patel et al., 2007). Therefore, other social responsibilities might impact their mental well-being more than their neighbourhood environment (Bovier et al., 2004).

Our finding that total greenspace is not associated with better mental health in young adults does not follow previous research. Urban, agricultural and natural greenspaces should provide these same benefits to individuals; yet for this particular study, we found no association. The lack of association between total greenspace and young adult mental health brings an interesting mixed result in the realm of greenspace studies. Research within greenspace falls short in many aspects, especially in how to define greenspace and how to accurately measure exposure to greenspace. Gascon et al.'s (2015) systematic review presents limitations in how there is no standardised approach to measuring greenspace levels, specifically when using land-cover maps. Land-cover maps are inconsistent as the greenspace indicators and criteria differ among studies and are based on the researcher's discretion. This leads to inconsistent results and conclusions. In this present study, the total percentage of greenspace measure does not include street greenery or private green properties, such as gardens. This is a big gap in our research when in the Netherlands, much of the available greenspace is gardens and street greenery. In 2012, the Dutch Central Bureau of Statistics (CBS) found that 89 out of every 100

Dutch inhabitants are within 1 kilometre of greenspaces like parks, public gardens, open natural spaces or woodland areas. Community gardens provide space for social cohesion, one of the factors contributing to better mental health (De Haas, 2021; Lampert et al., 2021). Gascon et al. mentions that measuring greenspace with the NDVI standard proves to be more consistent as measures can be comparable across studies. Our contrasting result between the green vegetation variable and the total greenspace variable highlight this potential factor in greenspace studies.

Greenspaces benefit individuals' mental health in numerous ways. However, the extent of benefits could differ among individuals based on their SES. Previous research suggests that greenspaces provide greater mental health benefits for vulnerable and lower socioeconomic populations (Barakat & Yousufzai, 2020; Gascon et al., 2015). In this analysis, SES was not a moderating factor towards better mental health. Moreover, we saw no association for the varying SES levels; for example, individuals with lower parental SES did not benefit from greenspace more than their higher parental SES counterparts. The lack of SES results may be due to the dataset's skew towards predominantly medium to high SES individuals. We tried to make up for this disproportionately high SES sample, by recoding parental SES using the lowest level of education among the parents. Although this created variance in our SES data, it might not be an accurate portrayal of the participants' actual SES. Previous studies indicate that lower SES individuals show more beneficial effects of greenspace than affluent people (Rigolon et al., 2021); therefore the lack of results potentially is due to the high SES sample.

Moreover, we measured SES based on the highest level of education recorded. For the individual participants, we measured SES by taking their level of education at age 17 or 20. As some did not answer their level of education at age 20, we had to take their education level at 17. In our analysis, we took the mental health scores of the participants at age 23, leaving a 4-6 year gap where the individual could have continued onto higher education (HBO and University), and in turn, moved up an SES level. For the parental SES, we combined both parents' highest level of education, by taking the lower level. Although there is some correlation between education level and income, there are many limitations to using education level as an indicator of SES (Geyer et al., 2006). Some issue with using the highest level of education as SES indicators is that education plays different roles in cultures and society (Shavers, 2007). For lower SES families, education may be more significantly present throughout a child's life, encouraging the child to pursue higher levels of education and in turn, move to a higher SES level. For individuals with higher SES families, education may not be as important to the individuals and perhaps not as necessary (Shavers, 2007; De Graaf et al., 2000). Moreover, education and income effects are outcome specific and depend on the individual. Using education and income interchangeably for SES can alter our results.

A strength of this present study is that we combined the greenspace variables to create the cumulative exposure. As participants could have moved from various locations, it was important to create an average greenspace exposure variable to account for the location differences. Moreover, as the environmental context of where one grew up is important, studying the exposure to greenspace during the adolescent years is highly influential on mental wellbeing. Additionally, sub-sectioning the data by low, medium and high SES was helpful in viewing the individual effects of greenspace on mental health per level of SES.

This study was limited by a small sample size. As we only wanted to include the participants where we had a complete greenspace exposure score from ages 11, 14, 17, and 20, we reduced our sample size to 34.04% of the baseline sample. We could have opened up the criteria of participants to include more of the sample size. With that being said, the PIAMA data is an ongoing project. Greenspace exposure at age 23 will be available in the next coming months. It might be interesting to redo this study to focus on the cumulative exposure to greenspace at ages 11-23 on mental health at age 23.

Unlike other research with this dataset, our study measured mental health on a continuous scale rather than the dichotomous MHI-5 standard where scores over 60 indicate better mental health. We chose to keep the measure on a continuous scale because the average mental health score was 63.90, which is technically considered better mental health but is a low average. Perhaps this research should have included both continuous and dichotomous models to see if there are different results for mental health.

With the rise of urbanisation, our access to greenspaces is decreasing. Nature is important to the health and wellbeing of individuals, society and our earth. If we continue to study greenspace and its benefits, we will be able to provide reasoning and shift the political agenda to be more environmentally friendly. This will, in turn, allow us to create more interventions and policies that will prioritize greenspace and nature. From this study, we recommend for social scientists to develop a standardised definition of greenspace. In creating a standard criteria for what greenspaces entail, we will be able to do more in-depth studies on what specific qualities of greenspaces are important to individuals.

In conclusion, green surroundings are beneficial to individuals' mental health. All individuals benefit from greenspaces differently, whether that be based on SES, gender, or even introversion. Understanding how various types of greenspaces play a role in individuals' mental health is astronomical in providing that equal factor for everyone to utilise. By 2050, most of the world will be living in urban cities. Let's make sure there are still greenspaces because concrete jungles are not where dreams are made of.

Appendix 1: Ethics Approval

P.O. Box 80140, 3508 TC Utrecht The Board of the Faculty of Social and Behavioural Sciences Utrecht University P.O. Box 80.140 3508 TC Utrecht	**Faculty of Social and Behavioural Sciences** Faculty Support Office Ethics Committee **Visiting Address** Padualaan 14 3584 CH Utrecht

Our Description	22-0360	
Telephone	030 253 46 33	
E-mail	FETC-fsw@uu.nl	
Date	03 February 2022	
Subject	Ethical approval	

ETHICAL APPROVAL

Study: Greenspace Exposure and Socioeconomic Status Inequalities in Mental Wellbeing

Principal investigator: C.K. Phan

Supervisor: Dom Weinberg

The study is approved by the Ethical Review Board of the Faculty of Social and Behavioural Sciences of Utrecht University. The approval is based on the documents sent by the researchers as requested in the form of the Ethics committee and filed under number 22-0360. The approval is valid through 30 June 2022. The approval of the Ethical Review Board concerns ethical aspects, as well as data management and privacy issues (including the GDPR). It should be noticed that any changes in the research design oblige a renewed review by the Ethical Review Board.

Yours sincerely,

Peter van der Heijden, Ph.D.
Chair
This is an automatically generated document, therefore it is not signed

Appendix 2: Instruments

Codebook of the PIAMA dataset was shared by the supervisor.

Appendix 3: SPSS Syntax

```
DATASET ACTIVATE DataSet1.
DESCRIPTIVES VARIABLES=Gender YoungAdultSES ParentsSESLow
  /STATISTICS=MEAN STDDEV MIN MAX.
FREQUENCIES VARIABLES=Gender YoungAdultSES ParentsSESLow
  /ORDER=ANALYSIS.
CORRELATIONS
  /VARIABLES=MHI_23_Continous AverageNDVI_3km AverageTotal_green_3km
ParentSESLowDummy_1
    ParentSESLowDummy_3 YoungAdultSESDummy_1 YoungAdultSESDummy_3 Gender
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  /MISSING=PAIRWISE.
REGRESSION
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  /MISSING LISTWISE
  /STATISTICS COEFF OUTS CI(95) R ANOVA
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  /NOORIGIN
  /DEPENDENT MHI_23_Continous
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REGRESSION
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```

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  /MISSING LISTWISE
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REGRESSION
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  /NOORIGIN
  /DEPENDENT MHI_23_Continous
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SORT CASES  BY ParentsSESLow.
SPLIT FILE LAYERED BY ParentsSESLow.
REGRESSION
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  /STATISTICS COEFF OUTS CI(95) R ANOVA
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YoungAdultSESDummy_3.
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REGRESSION
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YoungAdultSESDummy_3.
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SORT CASES  BY YoungAdultSES.
SPLIT FILE LAYERED BY YoungAdultSES.
REGRESSION
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  /MISSING LISTWISE
  /STATISTICS COEFF OUTS CI(95) R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT MHI_23_Continous
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REGRESSION
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REGRESSION
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  /DEPENDENT MHI_23_Continous
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ParentSESLowDummy_3.
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  /STATISTICS COEFF OUTS CI(95) R ANOVA
  /CRITERIA=PIN(.05) POUT(.10)
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REGRESSION
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  /MISSING LISTWISE
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```

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  /DEPENDENT MHI_23_Continous
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