

Chapter 5

The Influence of Socio-economic and Socio-demographic Factors in the Association Between Urban Green Space and Health



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Abstract Green spaces can help preventing potential negative health outcomes from climate change and urbanisation. Urban green spaces may reduce cardiovascular diseases exaggerated by heat stress or noise because of their climate regulation and noise-buffering potential. Urban green space may also promote physical activity and social interactions, and thus improve the physical and mental health of residents who tend to be more stressed in urban environments. Research findings on associations between urban green space and health outcomes are, however, not consistent, and potential relationships are often affected by confounding factors. In this chapter, a systematic review of the association between urban green space and health is presented, with a particular focus on socio-economic and socio-demographic confounders that may over-ride potential associations. Results show that there is some positive effect of urban green space on mental health and cardiovascular diseases. However, evidence is weak as many other studies show that socio-economic confounders, such as household income or neighbourhood deprivation, have the highest impact. The mediating effect of urban green space to decrease health inequality among different socio-economic groups may be more important. Based on the results of the review, conclusions are drawn on how to design green space that is beneficial for the health and well-being of all population groups including the vulnerable groups of children, the elderly and deprived people. This field of research is growing, and important prospects for future research on urban green and health are highlighted.

Keywords Green space · Urban · Health · Well-being · Confounder

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Highlights

- A systematic review of the association between urban green space and health is presented.
- The focus has been on socio-economic and socio-demographic confounders.
- Results show some positive association between urban green space, mental health and cardiovascular diseases.
- Evidence is rather weak, and socio-economic confounders have the highest impact on health outcome effects.
- The mediating effect of urban green space to decrease health inequality among different socio-economic groups may be more important.

5.1 Introduction

The value of urban nature has been considered within a range of societal challenge areas in cities, such as water management, air quality, urban biodiversity, and human health and well-being (Raymond et al. 2017). Assessments of these values – mostly using the ecosystem services (ESS) concept – are now informing urban policy and planning across the world. For example, at the international level, the Intergovernmental Panel on Biodiversity and Ecosystem Services discusses the benefits of nature for people as one way to promote nature’s values in environmental decision-making, for example, through the ESS concept and other human-nature inter-relations (Díaz et al. 2018). The integrated view to sustainable urban development is also highlighted in the 2030 Agenda for Sustainable Development and its sustainable development goals (SDGs), the New Urban Agenda adopted at the United Nations’ HABITAT III conference and promoted by the European Commission’s research and innovation policy on nature-based solutions. In particular, Goal 11 of the SDGs underlines that “Making cities safe and sustainable [...] involves [...] creating green public spaces, and improving urban planning and management in a way that is both participatory and inclusive” (The United Nations Development Programme (UNDP) 2015). Urban green spaces such as parks, allotment gardens, street trees, urban gardens, cemeteries, green roofs and green facades were shown to increase sustainability in urban areas. Urban green spaces ameliorate high temperatures in cities (Bowler et al. 2010), reduce noise, help filter pollutants from the air, and improve water inflow in times of extreme precipitation events (Haase et al. 2014). When developing new green spaces to make cities (more) sustainable, a key component for urban planning is to consider the spatial location of urban green spaces within the urban area, in order to understand their potential role in mediating improved health outcomes for groups of people.

Interest in research has recently increased regarding the role that urban green spaces may play in improving the health of urban residents (Hartig et al. 2014). One aspect that has been discussed is whether urban green can act as a health promoter by encouraging more active lifestyles, or as a disease preventer through reducing the impact of negative environmental conditions such as extreme weather events, air pollution, noise or heat (Kabisch et al. 2017; van den Bosch and Ode Sang 2017).

The reduction of the impact of negative environmental conditions is hypothesised to occur through providing ecosystem services, as presented above. In particular, van den Bosch and Ode Sang (2017) showed that urban green space contributes to the health of city residents by decreasing all-cause and cardiovascular disease-related mortality, adverse birth outcomes and mental disorders, particularly through providing regulating and provisioning ESS and through cultural ESS linked to socio-behavioural pathways. The authors, however, did not find significant results for sufficient evidence for stress reduction and physical activity as the mediating pathway.

They conclude that the impact of improving environmental conditions through urban green spaces is often spatially explicit, with an unequal distribution of environmental burdens and goods. In particular, disadvantaged and minority groups often bear higher environmental burdens such as noise or air pollution (Wolch et al. 2014), while they have less access to urban green spaces and the benefits they provide (Cook et al. Chap. 11, this volume). Clark et al. (2014) showed that low-income people are disproportionately exposed to air pollution in the USA, whereas Richardson et al. (2013) demonstrated a similar relationship for particular areas in Europe. Wolch et al. (2005) found that park availability is reduced in deprived neighbourhoods. Street trees, as a particular part of the green infrastructure network, have also been found to be differently distributed according to neighbourhood socio-economic status (Landry and Chakraborty 2009). Interestingly, Timperio et al. (2007) could not find any statistically significant relationship that urban green spaces are more scarce in low-income or minority neighbourhoods in Australia (Timperio et al. 2007). A recent review of park access by Rigolon (2016) also showed inconclusive findings for distance to parks but striking differences for size and quality of parks, with smaller park sizes and lower quality of parks for neighbourhoods of low socio-economic and minority groups. This suggests a more complex link between urban green space availability and accessibility and socio-economic differences, which depends on the indicators used for measuring greenness, availability and quality features of urban green spaces.

The relationships between environmental burdens, green space accessibility, socio-economic factors and potential health outcomes are still not clearly understood, and vary between studies. A structured systematic review is presented in this chapter to help close this gap in the research. In particular, effects of urban green spaces on urban health depending on accessibility and socio-economic status/trends are investigated. The term ‘socio-economic confounder’ is used in this chapter to describe factors that have a potential effect on health and that may even over-ride a potential association between urban green space and health outcomes.

5.2 Methods

A systematic, structured and quantitative literature review of peer-reviewed articles that were published in international scientific journals was conducted in November 2017. This review identified 140 papers of which the highest proportion were

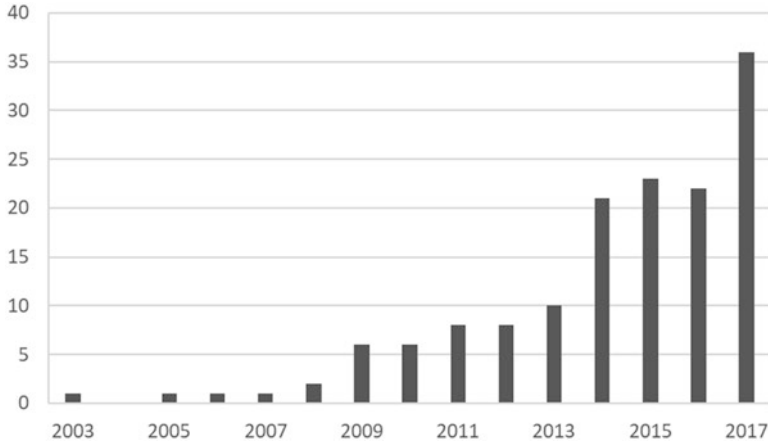


Fig. 5.1 Number of papers published in Web of Science on the relationship between urban green spaces and potential health effects

published within the last 5 years (2013–2017, Fig. 5.1). The analysis was therefore restricted to papers published in English from 2013 onward to highlight recent advances in the subject. Web of Knowledge[®] was used as the scientific search engine to find appropriate articles. The search profile was based on a number of primary search terms related to particular categories related to the topic. The first main term related to the topic ‘urban green’, the second to ‘availability’ and ‘access’, the third to socio-economic and socio-demographic profile of neighbourhoods or affected populations, and included key search terms such as ‘income’, ‘age’ or ‘class’, and the fourth to health including terms such as ‘health’, ‘disease’ and ‘well-being’. The respective terms were chosen based on the author’s own experiences with the topic and other reviews, existing theories and initial literature studies that revealed some inconsistent relationships on the green space associability link. The operators AND between and OR within categories were used. It was decided to restrict the search to scientific peer-reviewed papers. Excluded from the literature search were research reports and other non-scientific publications or bibliographies. However, these were used in searches for additional literature as was done with other existing reviews that touched on the topic (Kabisch et al. 2017; van den Bosch and Ode Sang 2017). Articles found through the search strategy were screened and included in the final sample if the content matched the main research objectives. An article was evaluated as not relevant if no direct link to health outcomes related to urban green could be found, or when the article presented a method only as main content. This strategy resulted in a total of 25 papers. All final articles were analysed using a standardised data extraction sheet based on pre-defined questions for review. This included general information such as publication date, case-study location, respective scale of interest, particular assessment method or data used.

5.3 Results

The relationship between urban green spaces and potential health effects is a growing research field, with an increasing number of publications, particularly since 2013 (Fig. 5.1). The research discussed here focusses on those studies that considered differences in the socio-economic and socio-demographic context of the population groups studied. In addition, the particular green space metrics, buffers and data used in the study are considered as it was assumed that there might be a difference in health outcome results when different measures are used. Only 25 papers were directly related to a health outcome linked to urban green space use or availability. The remaining papers indirectly address a health outcome by mentioning a potential health benefit of green space exposure for different population groups in the abstract but not analysing health outcome as a main aim. Papers that address health directly mostly deal with mental health outcomes followed by studies on physical activity, birth outcome, overweight, general health and cardiovascular diseases. Results are presented in Table 5.1 and summarised with main associations indicated in Fig. 5.4.

5.3.1 *Mental Health and General Health*

Cohen-Cline et al. (2015) studied potential associations between access to green space and self-reported depression, stress and anxiety. When adjusted for confounding factors such as income, the association between urban green space and less depression remained significant. Mukherjee et al. (2017) found a similar association between the nearest park size and depression even when controlling for confounders such as household wealth and education. They showed that a smaller size of the nearest park was associated with higher odds of depression. Controlling for socio-economic status, Triguero-Mas et al. (2015) identified that surrounding green spaces were associated with better mental health. Mitchell et al. (2015) found improved mental health in lower income groups when access to green space and recreational areas improved. A similar relationship was found by Feda et al. (2015), who showed an inverse association between accessibility of urban parks and perceived stress among adolescents when controlled for socio-economic status. Thompson et al. (2016) identified that higher quantity and better access to green spaces including gardens and allotments were significantly related to decreased stress levels in deprived communities.

For 3- to 5-year-old children, Flouri et al. (2014) found that in lower income groups, children with a higher percentage of green space in their neighbourhood had fewer emotional problems. For a study of 4- to 6-year-old children, those with comparatively more park and natural area space around their homes had better mental health outcomes. Interestingly, Astell-Burt et al. (2014) showed that the green space-mental health association varies across the life course and between

Table 5.1 The main characteristics and results of studies on greenness and health by confounding factors

References	Country, city	Aim	HEALTH	Study design	Green space metrics and buffer	Confounder	Main results
Abelt and McLafferty (2017)	U.S., New York	Assessment of relationship between mothers' exposure to green and blue spaces and adverse birth outcomes.	Birth outcome	Mixed-effects linear and logistic regression models; GIS analysis	NDVI in buffers of 100 m, 250 m and 500 m, NYC Street Tree Census	Neighborhood deprivation, education, race, marital status, population density, birth place	No consistent significant relationship between adverse birth outcomes and residential greenness in fully adjusted models. Deprived tracts were less "green" and closer to major roads and industrial land use. Significant association between street trees surrounding the home and reduced odds of preterm birth were identified
Allan et al. (2017)	UK, England	Investigation of health variations by residential contexts, its causes and sensitivity to rural-urban classifications	General health (Limiting long-term illness)	Logistic regression models applied to UK census data (2001)	Rural-urban classification, no buffer used	Employment status, education, age, sex, marital status, ethnicity	A positive urban-rural health gradient was identified, with the exception of a protective "capital city" effect.
Astell-Burt et al. (2014)	UK, country scale	Analysis of variation in minor psychiatric morbidity	Mental health	Longitudinal study with data from nine annual waves of the British Household Panel Survey (1996-2004) using multi-level linear regression	Green space, no buffer used	Employment status, income, education, tenure status, age, gender, marital status	Psychiatric morbidity appeared less prevalent among residents living in greener neighbourhoods. In those areas, residents had higher household income. The link between urban green space and health varied across the lifecourse

Calogiuri et al. (2016)	Norway, country scale	Examination of green exercise as a physical activity across social groups.	Physical activity	Questionnaire survey (2168), reported weekly green exercise and other forms of physical activity, specific forms of GE, and perceived factors that promote GE	Green exercise (=physical activity taking place in natural environments), no buffer used	Income, education, sex, age	Green exercise was represented among the elderly. No associations were identified to sex, centrality, education level or household income
Cohen-Cline et al. (2015)	U.S., Washington	Assessment of the association between green space access and self-reported depression, stress and anxiety in between twin pairs.	Mental health (self-reported depression, stress and anxiety)	Multi-level random intercept model of same-sex twin pairs (4338 individuals) from the community-based University of Washington Twin Registry	NDVI based, no buffer used	Income, neighborhood deprivation, sex, age, ethnicity, population density, physical activity	Only the association between green space and depression was significant in fully adjusted models. Association between green space and stress became non-significant when adjusted for confounders
Cusack et al. (2017)	U.S., Portland and Austin	Identification of a relationship between multiple urban green space metrics and term birth weight.	Birth outcome (term birth weight)	Vital Statistics data for a birth cohort (2005–2009), Correlation between green space metrics and mixed models	NDVI, % tree cover, % green space, % street tree buffering and access to parks (using US EPA EnviroAtlas Data), multiple buffer distances: 50 m, 250 m, 300 m, 500 m, 1000 m	Education, income, age, sex, ethnicity, population density	In fully adjusted significant associations disappeared. Maternal race, ethnicity and education as confounders were mostly reducing green space and birth weight associations

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Table 5.1 (continued)

References	Country, city	Aim	HEALTH	Study design	Green space metrics and buffer	Confounder	Main results
Feda et al. (2015)	U.S., Buffalo	Assessment of the association between neighbourhood park area and perceived stress among adolescents, while controlling for physical activity.	Mental health (perceived stress)	10-week Neighbourhood Environment study, GIS analysis, multivariate regression model	Parks, classification of high/low park access using a park access index, 800 m buffer distance	Socio-economic status (SES), race/ethnicity, housing density, physical activity	Park area was significantly associated to perceived stress also when controlling for socio-economic status. Physical activity and gender were not significant as confounder in fully adjusted models
Flouri et al. (2014)	UK, England	Analysis of the effect of urban neighbourhood green space on young children's emotional and behavioural adjustment and resilience.	Mental health (emotional and behavioural problems from early to middle childhood)	2000–2007 Millennium Cohort Study data on families in England whose children had emotional and behavioural problems living in urban neighbourhoods	Neighbourhood green space was measured using the 2001 Generalised Land Use Database, excluding domestic gardens, no buffer used	Tenure status, income support, poverty, education, sex, ethnicity, age, household composition	Green space appeared unrelated to child adjustment on the whole, but it predicted emotional resilience. Poor children with more green space in their neighbourhood had fewer emotional problems from age 3 to 5, relative to those living in less green neighbourhoods
Kihal-Talantikite et al. (2013)	France, Lyon	Exploration of a risk cluster of infant mortality according to neighbourhood characteristics	Infant mortality	Cluster analysis assessing spatial aggregation. 715 cases of infant deaths (2000–2009) obtained by city halls in Lyon	Green space index, calculated by using land cover datasets, no buffer used	Neighbourhood deprivation	Spatial distribution of infant mortality resulted to be not random but the high-risk cluster disappeared after controlling for greenness level and socio-economic deprivation. Both deprivation and greenness levels seem to have an independent effect

Jenkin et al. (2015)	New Zealand, country scale	Identification of neighbourhood characteristics associated with children's unhealthy behaviour.	Obesity (BMI), and weight-related behaviours (physical activity, diet, etc.)	Logistic regression models with individual-level data for children from 2006/7 New Zealand Health Survey	Green space (measured in distance and proportion in neighbourhood), no buffer used	Neighbourhood deprivation, income, education, employment status, tenure status, age, sex, ethnicity, household composition	Greater access to green space was significantly associated with lower sugar-sweetened beverage consumption next to neighbourhood deprivation, which was also significantly positively associated with other negative health behaviours
McMorris et al. (2015)	Canada, country scale	Analysis of associations between residential greenness and physical activity.	Physical activity	2001 Canadian Community Health Survey data, logistic regression	NDVI around home, buffer distances: 30 m, 500 m	Income, sex, age, marital status	Association was most significant for those in the higher income groups but positive associations were observed between greenness and physical activity in all income groupings Higher income households lived in areas with higher greenness
Michael et al. (2014)	U.S., Portland	Examination of the effect of a neighborhood-changing intervention on changes in obesity in older women	Obesity (BMI)	Retrospective cohort design, change in BMI and neighborhood built environment over 18-year period (1986–2004) among older women; structured interviews and clinical examinations	Green space proximity using Euclidian distance from participant's residence to closest public park or green space. no buffer used	Occupational manual labor = employment status?, socio-economic status (SES), age, education	No significant association between changes in neighborhood walkability or parks and green spaces and variation in BMI over time was identified in fully adjusted models. SES, education, age among others appeared to be significant in adjusted models

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References	Country, city	Aim	HEALTH	Study design	Green space metrics and buffer	Confounder	Main results
Mitchell et al. (2015)	Europe, urban areas	Identification of potential neighbourhood characteristics associated with narrower socio-economic inequalities in mental well-being.	Mental health	Multi-level regression models using data of the 2012 European Quality of Life Survey	recreational/green areas non-specific, no threshold, participants were asked about accessibility (with great difficulty, with some difficulty, etc.)	Education, employment status, sex	Socio-economic inequality in mental well-being was significantly narrower among respondents reporting good access to green/recreational areas, compared with those with poorer access
Mukherjee et al. (2017)	India, Delhi	Analysis of the association between park availability and major depression.	Mental health (depression)	Questionnaire survey data from the baseline cross-sectional survey of the Centre for Cardio-Metabolic Risk Reduction in South Asia (CARRS); mixed-effects logistic regression models; development of park availability index with GIS	Park availability index with a buffer of 1-km distance	Education, employment status, income, age, gender, marital status, household composition	In adjusted models a significant association between area of nearest park and major depression remained and smaller park areas were associated with higher odds of depression

Nichani et al. (2017)	New Zealand, country scale	Analysis of association between green space exposure during pregnancy and depression	Mental health (antenatal depression)	Adjusted logistic mixed effect models; data from the Growing Up in New Zealand study, a longitudinal pre-birth cohort study; GIS analysis	Proportion of green space within Census Area Unit including parks, beaches, urban parklands/ open spaces, forests, grasslands, and croplands, but excluded private gardens, no buffer used	Education, employment status, neighbourhood deprivation, age, ethnicity, marital status, socio-economic status	No associations between green space and antenatal depression could be found. Even when adjusted for relevant factors such as deprivation
Padilla et al. (2016)	France, Nice	Assessment of diverse socio-economic, health, accessibility, and exposure factors to explain how they are linked to environmental health inequalities related to infant and neonatal mortality	Infant and neonatal mortality	Creation of environmental indicators with GIS. Multiple Component Analysis, Hierarchical Clustering and standard Poisson regression models using official statistics collected from death certificates in the city halls of Nice municipalities	Green space provided by Corine Land Cover data including natural area but not agricultural areas. Proportion of green area in census block with 10 m ² of green space per inhabitant	Neighbourhood deprivation	Identified a significant relationship between infant and neonatal mortality risk and level of deprivation, but the link to urban green space and other exposure variables was not entirely clear. Deprivation was significantly positively correlated to proximity to high-traffic roads and negatively correlated to the proportion of green space as well as to the distance to respective health-care facilities

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Table 5.1 (continued)

References	Country, city	Aim	HEALTH	Study design	Green space metrics and buffer	Confounder	Main results
Paquet et al. (2013)	Australia, Adelaide	Assessment of associations between accessibility, greenness, size, and type of public open spaces and clinical risk markers for cardiometabolic diseases and mediating factors.	Cardiometabolic risk	Data from the 2000–2003 North West Adelaide Health Study, a longitudinal cohort; Poisson regression models; GIS analysis	NDVI, accessibility of public open spaces within 1000 m road-distance from participant's residence buffer	Education, income, socio-economic status (SES), gender, age	The number and proportion of public open spaces were not statistically significantly related to cardiometabolic health but greenness, size, and type were inversely related to cardiometabolic health
Pearson et al. (2014)	New Zealand, country scale	Assessment of environmental factors in reducing obesity and promoting physical activity.	Weight (overweight, obesity, both), weight-related behaviours (physical activity, vegetable and fruit consumption)	Logistic regression models using data from the 2006/2007 New Zealand Health Survey based on face-to-face interviews	environmental characteristics (e.g. food outlets and green space [...]), Accessibility of useable green space, Proportion of meshblock consisting of useable green space), no buffer used	Neighbourhood deprivation, age, gender, ethnicity	Increased neighbourhood deprivation and decreased access to neighbourhood green space were significantly associated with risk of overweight and/or obesity. Increased access to green space was associated with high levels of walking. Significant trend for low levels of walking was additionally positively associated with neighbourhood deprivation

Richardson et al. (2017a)	U.S., Pittsburgh	Examination of influence of neighbourhood green space, walkability and crime on physical activity in low-income African American adults.	Physical activity	Self-reported data on demographics, functional limitations, objective measures of physical activity using accelerometry, neighbourhood green space using GIS, and walkability via street audits in 791 predominantly African-American neighbourhoods	Calculation of green space area surrounding each participant's household within 1-km network buffer	Income, education, number of crimes reported, age, marital status	No significant association was found between neighbourhood green space, walkability, incidents of crime and physical activity
Richardson et al. (2017b)	UK, Scotland	Assessment of a potential relationship between neighbourhood natural space and private garden access and children's developmental change over time	Mental health (emotional and behavioural difficulties)	Longitudinal data of 4- to 6-year-old urban children from the Growing Up in Scotland (GUS) survey; random-intercept repeated-measures linear models	Area (%) of total natural space and parks within 500 m of child's home using Scotland's Greenspace Map, buffer of 500 m	Education, income, neighbourhood deprivation, age, sex	Groups with more park or total natural space close to their homes had slightly better social, emotional and behavioural health outcomes. Having access to a garden was related to sizeable mental health benefits (children from degree-educated households over those from households with no educational qualifications)

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Table 5.1 (continued)

References	Country, city	Aim	HEALTH	Study design	Green space metrics and buffer	Confounder	Main results
Roe et al. (2016)	UK, London, West Midlands, Greater Manchester	Exploration of relationship between general health and individual, social and physical environmental predictors in deprived white British and black and minority ethnic groups.	Self-reported general health, physical activity	Household questionnaires (face-to-face interviews); Chi-Squared Automatic Interaction Detection (CHAID) segmentation analyses, Correlated Component Regression analyses	Wards identified via land use classifications, perception and use of local green space asked in interviews, no buffer used	Income, employment status, age, ethnicity, gender	General health in the “worst” health group (i.e. ethnicities within the Mixed group) was significantly more likely to be predicted by urban green space usage and perception variables than in any other ethnic group
Roe et al. (2017)	UK, two areas in Central Scotland	Analysis of the effect of urban nature on stress reduction in different segments of deprived urban communities.	Mental health (stress reduction)	A cross-sectional household questionnaire administered by a survey company, using a face-to-face, computer-assisted interviews; Latent Class Analysis	Green space includes parks, woodlands, scrub and other natural environments. Perception of green space access, quantity and quality and motivation for visiting green space was asked in survey, quantity of green space through a datazone green space measure, no buffer used	Education, neighbourhood deprivation, age, gender	Our study found that the opportunities in the immediate neighbourhood for stress reduction vary by age. Stress coping in youth is likely supported by being social and keeping physically active outdoors, including local green space visits. By contrast, local green space appears not to support stress regulation in young-middle-aged and older adults, who choose to stay at home

Thompson et al. (2016)	Scotland, Edinburgh and Dundee	Assessment if the use of local green space is associated with stress in deprived urban communities.	Mental health (stress)	Cross-sectional survey of 406 adults in four communities of high urban deprivation in Scotland, UK; Correlated Component Regression	Self-reported access to green space asked in survey. Green space based on reclassifications of the Ordnance Survey MasterMap and a city-wide audit of green space for Edinburgh and cross-referencing, no buffer used	Education, neighbourhood deprivation, employment status, age, sex, marital status	Quantity of green space in the neighbourhood, and access to garden or allotment, were significantly predicting of stress in deprived communities
Triguero-Mas et al. (2015)	Spain, Catalonia	Assessment of the association between natural outdoor environments and general and mental health.	Self-reported general and mental health	Cross-sectional data from adults interviewed in Catalonia (Spain) between 2010 and 2012 as part of the Catalonia Health Survey; logistic regression and negative binominal models	NDVI, access to green spaces, access to blue spaces, exposure to natural outdoor environments within 300 m from residence; sensitivity analyses used 100-m, 500-m, and 1 - km buffers	Education, socio-economic status (SES), gender, age, marital status, population density	Green spaces were significantly associated with better self-perceived general health and better mental health, particularly. Results remained significant for different buffers, and when stratifying for socio-economic status. No association between green spaces and social contacts and physical activity. The results for blue spaces were not conclusive

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Table 5.1 (continued)

References	Country, city	Aim	HEALTH	Study design	Green space metrics and buffer	Confounder	Main results
Xu et al. (2017)	China, Hong Kong	Analysis of the relationship between green space and mortality.	Mortality (cardiovascular, diabetes, chronic respiratory, lung cancer mortality)	Mortality data for every registered death during the period of 2006–2011 from the Hong Kong Census and Statistics Department; Negative binomial regression models; Generalised Estimating Equations; GIS analysis	NDVI, no buffer used	Income, education, employment status, population density, sex	Higher NDVI values were significantly associated with lower cardiovascular and diabetes mortality, and non-significantly associated with lower chronic respiratory mortality. Associations were stronger for males and low-income area residents

gender. For males, the benefit of green space emerged in early adulthood, while no association was identified for women until later in life. Finally, Nichani et al. (2017) did not identify any associations between green space and depression in pregnant women.

Relatively consistent results show that urban green space has some positive effect on mental health in most age groups, in particular for children, but also for different deprived groups. The effect mostly remained even after controlling for socio-economic confounders such as SES, area deprivation, household income or educational status.

5.3.2 Birth Outcome

Abelt and McLafferty (2017) found no consistent significant relationship between birth outcomes and residential greenness. They did, however, identify an inverse relationship between street-level vegetation (street trees) and odds of preterm birth, which remained after controlling for the mother's socio-economic status. Adverse birth outcomes, such as preterm birth or low birth weight, were generally higher among women residing in deprived areas. These deprived areas were less green and had lower numbers of street trees. Similar inconsistencies in results were identified by Cusack et al. (2017). They could not show significant associations between green space and birth weight in full models that take confounders such as ethnicity into account. They did, however, find some consistent associations for the high density urban areas and green space measured at small buffer distances. Adjusted models showed that parents' race/ethnicity had the strongest influence on model predictions, whereas the inclusion of environmental confounders such as NO₂ and air pollution had no effect on the NDVI and birth-weight association (see also Dadvand et al. Chap. 6, this volume). Kihal-Talantikite et al. (2013) also included deprivation as a confounding variable to greenness, and showed that there was no difference in the results for infant mortality. Nevertheless, infant mortality rates were not randomly distributed over the study area, showing that both greenness and deprivation may have an impact. Padilla et al. (2016) could not identify a significant association between neonatal mortality and urban green-space exposure. Kihal-Talantikite et al. (2013) and Padilla et al. (2016) found a significant association between neonatal mortality risk and level of deprivation.

Clearly, there is a major link between socio-economic status or deprivation and birth outcomes. Only some studies could show a relationship with urban green space.

5.3.3 *Overweight*

Three of the reviewed studies have researched the link between green space availability and overweight or obesity in urban areas. Pearson et al. (2014) showed that deprivation and decreased access to green space in the neighbourhood were both significantly linked with higher odds of being overweight or obese. However, for a sample of older women, Michael et al. (2014) could not identify any association with overweight or body mass index (BMI) and changes in the urban environment through, for example, green-space improvements. They did, however, as shown above, again identify a link between being overweight and socio-economic status. A higher socio-economic status of the neighbourhood was associated with a healthier BMI value. Jenkin et al. (2015) found unexpected results, in that more green space in the neighbourhood was associated with lower sugar consumption values. As shown, they also found neighbourhood deprivation to be significantly linked to obesity-related behaviours such as fast-food consumption.

The link between lower socio-economic status and risk of being overweight was identified in the presented studies, whereas the association with urban green space was only identified in one study.

5.3.4 *Physical Activity, Cardiovascular Disease and Mortality*

Recent research suggests that urban green space is associated with participation in physical activity and has, through this, a positive effect on health (see also Dadvand et al. Chap. 6 and Cook et al. Chap. 11, both this volume). McMorris et al. (2015) showed that residents living in areas with the highest share of green space were significantly more likely to be physically active during leisure-time. This relationship appeared in all income groups. Likewise, Pearson et al. (2014) showed that increased access to urban green space was directly associated with higher levels of walking. Low levels of walking were significantly positively associated with neighbourhood deprivation. By contrast, Richardson et al. (2017a) found no significant relationship between physical activity and neighbourhood green space in low-income African-American adults in a US city.

Paquet et al. (2013) showed that larger, greener and more locally available green spaces in particular were associated with better cardiometabolic health, which is particularly mediated through physical activity. Xu et al. (2017) showed that greater greenness was significantly associated with lower cardiovascular and diabetes mortality, and non-significantly associated with lower chronic respiratory mortality. Relationships were identified to be stronger for residents living in low-income areas.

Although one study could not find any significant association between physical activity and green space, all other review studies showed that urban residents are more physically active in greener neighbourhoods, although one study highlighted a lower degree of activity in deprived areas.

5.3.5 Green Space Metrics, Buffers and Data Used

A number of studies estimated green space or urban greenness with the average Normalised Difference Vegetation Index (NDVI; Abelt and McLafferty 2017; Cohen-Cline et al. 2015; McMorris et al. 2015; Paquet et al. 2013; Triguero-Mas et al. 2015; Xu et al. 2017). The NDVI is a measure of urban greenness based on remote sensing data.

Others use green space classifications based on land use or land cover data in official statistics (Fedaa et al. 2015; McMorris et al. 2015; Abelt and McLafferty 2017; Cusack et al. 2017; Mukherjee et al. 2017). Several studies use a distinct distance or buffer size from the residential place ranging from 30 m to 1000 m (Cusack et al. 2017; McMorris et al. 2015; Abelt and McLafferty 2017; Mukherjee et al. 2017; Fedaa et al. 2015). Remaining studies apply land-use and land cover data from official national or local statistics. Here urban green is classified as urban parks, urban woodlands or forest areas. Nearly half of the studies use buffer sizes of 500 m around a residential place or neighbourhood followed by a 250-m and 300-m distance. Those areas should reflect a walking distance of around 10 min to the next available green space of a certain size.

In general, it cannot be concluded that the results differ depending on the green space measurement, data or buffer size used (for further discussion, see de Vries and Snep Chap. 8, this volume).

5.3.6 Confounding Factors

Many studies researched the relationship between health outcome and urban green space exposure or availability while controlling for confounding factors in their statistical models. The articles selected for our review used a number of different socio-economic and socio-demographic variables (Figs. 5.2 and 5.3). Socio-economic

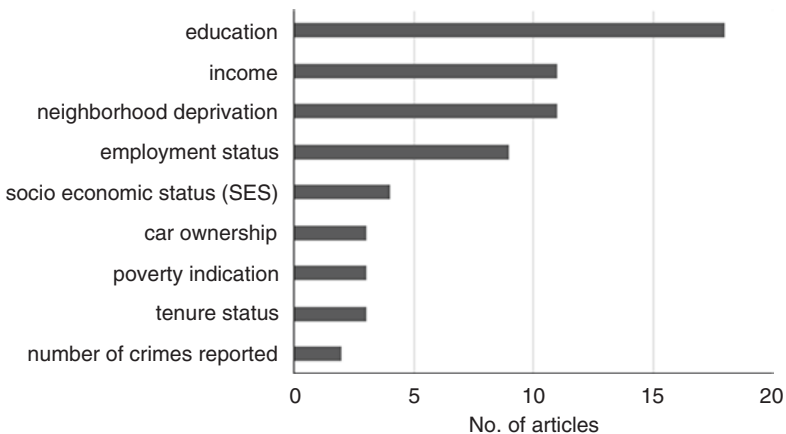


Fig. 5.2 Socio-economic confounders

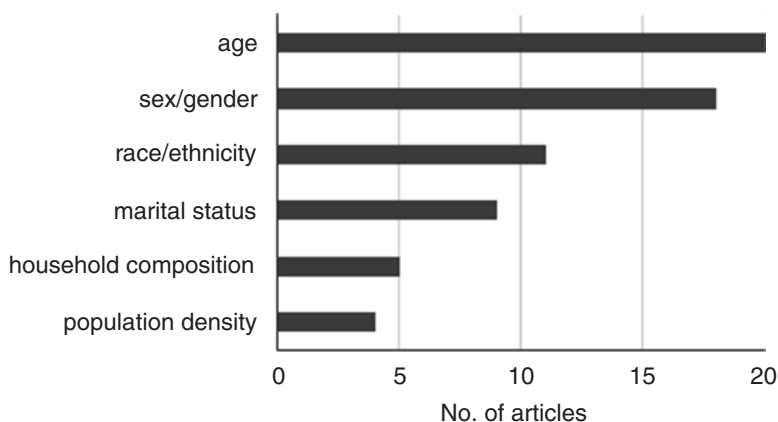


Fig. 5.3 Socio-demographic confounders

confounders mostly address variables of social status that include education of survey participants or households, followed by income or employment status.

For income, it was shown that a higher household income was found to be less likely for residents with psychiatric morbidity, and that this was less prevalent in greener neighbourhoods (Astell-Burt et al. 2014). Significant associations between greenness and physical activity were identified in all income groups (McMorris et al. 2015). Mukherjee et al. (2017) showed that park size was significantly negatively associated with depression even when models were adjusted for confounders such as income, education or employment status, but also for age, gender, marital status and household composition. Similarly, Calogiuri et al. (2016) and Nichani et al. (2017) found that socio-economic inequality in mental well-being was significantly lower among respondents reporting good access to a green space compared with those who had less access. Other studies, however, could not find any relationship between health outcome and socio-economic or socio-demographic confounders (Calogiuri et al. 2016; Nichani et al. 2017) or showed that significant associations between green space and health outcome became non-significant after models were adjusted for confounders (Cusack et al. 2017; Richardson et al. 2017a). For example, Padilla et al. (2016) showed that the significant association between green space and stress disappeared when models were adjusted for socio-economic confounders. A case study city in France showed a significant relationship between infant and neonatal mortality risk and level of deprivation, but could not clearly explain the link to urban green space (Kihal-Talantikite et al. 2013) (Fig. 5.4).

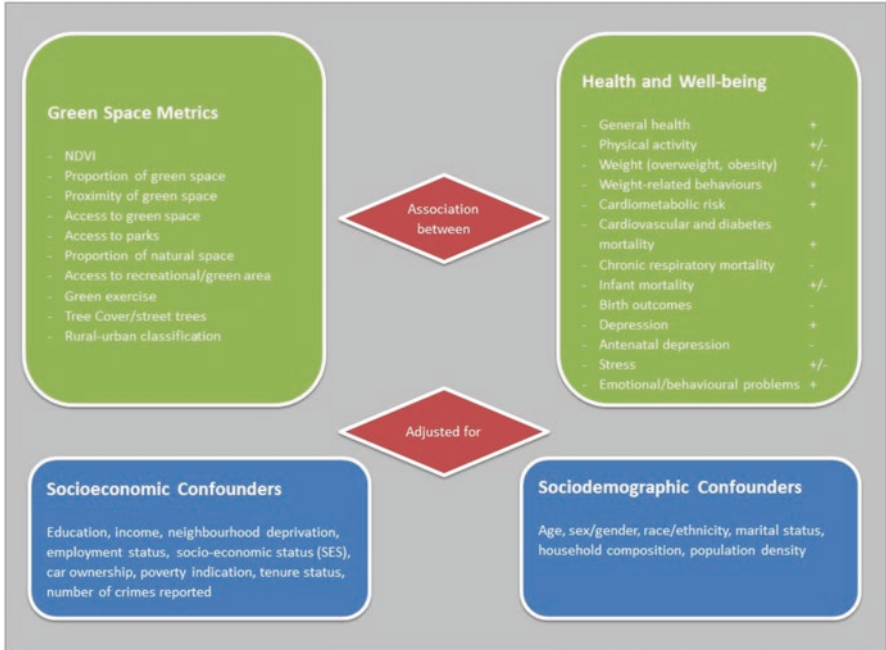


Fig. 5.4 The relationships between urban green space, and health outcomes and confounders, as treated in existing reviews. The strength of the evidence is indicated behind each health outcome: + significant association with evidence, – no signification association found; +/- weak evidence and no consistent results

5.4 Discussion

5.4.1 *Urban Green Space and Health Outcomes in Relation to Socio-demographic and Socio-economic Confounders*

This study presents the results of a systematic quantitative review that focuses on the association between green spaces and health outcomes with a particular focus on potential socio-economic and socio-demographic confounding factors. Based on the results of this review, it can be concluded that there is a positive association between urban green space and health outcome variables related to, for example, mental health, birth outcome, general health, overweight and other factors. The most consistent results were identified for the association between urban green space and mental health, in particular for children and adolescents. In a detailed review on the benefits of nature contact for children, Chawla (2015) impressively showed the protective effect of nature for psychological well-being irrespective of the method of measurement.

In a number of studies, the positive association between urban green space and health outcome remained even after controlling for socio-economic confounders such as SES, area deprivation, household income or educational status. However, associations are not significant in all studies and partly disappeared when statistical models were adjusted for socio-economic and socio-demographic confounding variables. The strongest remaining significance was shown here for mental health and physical activity. A similar conclusion was presented by Kabisch et al. (2017) for an association between urban greenness and health outcome for particular vulnerable groups of children and elderly. Consistent results were also shown for physical activity but not for overweight or obesity. We can conclude that results demonstrate a multi-factor association between socio-economic, socio-demographic and environmental/green factors and potential health outcomes.

Socio-economic and socio-demographic factors are particularly relevant, and often explain health outcomes to a greater extent than green space availability only. Variables that relate to a lower socio-economic status of participants explain more negative health outcomes. However, for mental well-being, inequalities were smaller among urban residents who reported good access to green spaces, compared with those reporting less access. Similar results were also found for health outcome variables other than mental health. Mitchell and Popham (2008) found that, in general, populations that are exposed to the greenest environments were also identified to have the lowest levels of health inequality linked to income deprivation (for further discussion, see Cook et al. Chap. 11, this volume). Further, the mediating effect of urban green space was highlighted for lower income or deprived groups (Flouri et al. 2014; Mitchell et al. 2015; Roe et al. 2017). Some green space and health relationships appeared to be stronger for those living in low-income areas (Xu et al. 2017). The mediating effect of urban green space may be particularly important for lower status groups. Chawla (2014) reported the importance of nature as a green refuge, with particular importance for children in the context of poverty and displacement.

Reasons for some inconsistencies in the results of the potential association between urban green space health outcomes depend on the particular inclusion variables. Some authors suggested that their results are different from other studies because of the non-inclusion of particular confounding factors such as environmental and neighbourhood characteristics of deprivation, crime, air pollution, etc. (Pearson et al. 2014). Furthermore, inconsistencies might be explained by the difference in green space provision in urban areas in different case studies (Richardson et al. 2017a).

5.4.2 Implications for Urban Policy and Planning

What can urban planning and policy-making learn from the studies discussed in this review? Goal 11 from the SDGs clearly states that creating green public spaces will be integratively linked to sustainable and safe urban development. But how is a

green space that is most beneficial for all population groups including the vulnerable groups of children, the elderly and deprived people designed?

In the review, green space assessments were conducted that focus on different types of green space, such as parks, street trees or house gardens. Small-scale urban green space such as tree canopies in cities have been shown to improve health effects such as birth outcome, mortality and restoration (Abelt and McLafferty 2017) (see also Lindley et al. Chap. 2, this volume). Small green spaces such as street trees, paths, greenways or gardens provide effective opportunities for restoration and stress reduction as types of micro-restorative settings (Mitchell et al. 2015; Triguero-Mas et al. 2015). The increase in the number of street trees in an urban neighbourhood and the maintenance of existing trees might be of particular importance in disadvantaged neighbourhoods as this could go hand-in-hand with potential positive effects for environmental justice (Landry and Chakraborty 2009; Abelt and McLafferty 2017). In the study by Cusack et al. (2017), it was shown that an increase in urban green space on smaller scales is particularly important in high density urban areas to improve birth outcomes. Further, a stronger association between green space and lower mortality rates was highlighted for those living in areas with higher population densities (Xu et al. 2017). The authors argue that the beneficial effects of green space, including physical exercise opportunities, pollution and urban heat island reduction, and stress relief, may be more needed among people living in more urbanised settings. To conclude, the implementation and maintenance of small-scale green spaces in the form of trees, but also green space within a 50-m distance, is particularly beneficial in high-density urban areas (Markevych et al. 2014; Casey et al. 2016).

In many articles, the authors pointed to the fact that the availability, accessibility and quality of urban green spaces is important for health benefits (Paquet et al. 2013). The size of the park might be one quality criteria that particularly relates to physical activity and mental health outcomes. It has been argued that larger parks in particular are related to a lower risk of cardiometabolic diseases and greater levels of physical activity, whereas studies that only focus on accessibility distance measures without considering any quality aspect could often not find any significant relationship between health outcomes and urban green space (Michael et al. 2014; Nichani et al. 2017). Mukherjee et al. (2017) found an inverse association between park size and depression. They suggested that large parks in particular may provide more benefits of green space exposure, because in their case study of Delhi, they are better maintained, have more natural spaces and diverse landscapes, and are more frequently visited, which translates into more opportunities to socialise. It can be concluded that the quality and a certain size but also the availability within a certain distance of an urban green space all play a role in motivating individuals to use outdoor spaces for physical activity (Jenkin et al. 2015; Mukherjee et al. 2017). Furthermore, the review results showed how green spaces equipped with playgrounds, sport areas, benches, toilets, lights, trees to provide shade, and good sidewalk quality and connectivity can play a more important role in green space use for health and well-being and should be considered in urban planning and decision-making (Michael et al. 2014). Particularly for children, green spaces provide places

to explore, play, discover and engage with nature, all important resources for mental well-being (Chawla 2015). This calls for green spaces that are not perfectly manicured but include diverse components of green such as adventure areas, wilderness areas, playgrounds, amongst others. This has been achieved in the development of the park 'Gleisdreieck' in the inner city area of Berlin, where local residents also took an active role in shaping and planning their local green space (Kabisch 2015; Rall et al. 2015).

With regard to the social and socio-economic context criteria, Richardson et al. (2017a, b) showed that children from low-education households had significantly less natural space in their neighbourhoods, and McMorris et al. (2015) found significant relationships between greenness and physical activity for all income groups. Increasing levels of greenness do therefore benefit all population groups, which should be taken into consideration in urban planning for future green space development and maintenance (Cook et al. Chap. 11, Davies et al. Chap. 12, and Heiland et al. Chap. 19, all this volume). Roe et al. (2016) highlighted the fact that particular patterns of use of urban green spaces differ significantly according to different ethnic and gender groups and needs to be considered by planners and policy-makers in a way to steer green space provision appropriately. This suggests that developing new green spaces needs to consider the local context carefully and sensitively.

Safety plays a major role in green space use. Urban green space might be available in significant quantity but is not used by the residential population because of safety concerns (Cohen et al. 2010). Perceived safety concerns and poor environmental quality of local green spaces may discourage residents from using these spaces (Dadvand et al. Chap. 6, this volume). Policy-makers and urban planners should act in these instances to make areas safer and decrease environmental pollution.

5.4.3 Directions for Future Research

Several studies have discussed that exposure and use of urban green space differs according to social and demographic background. Astell-Burt et al. (2014) discussed that exposure to green space varies in different stages in life and that these differences manifest in health disparities. People of different age groups may have different needs with regard to urban green spaces, which in turn translates into diverse health outcome effects (Roe et al. 2017). McMorris et al. (2015) identified an age-specific relationship to green space use for physical activity with significant results for associations between younger adults and women and lower associations with increasing age. In addition, Roe et al. (2017) showed that the use of green space and perception of green space quality does not only vary by age group but also by deprivation: Whilst younger people (youth) are using nearby green space

regularly and are satisfied with its quality, the same (or similar) outdoor space is not supporting the needs of young to middle-aged adults. The authors showed that judgements about the quality aspects of urban green space vary across age groups, but place more importance on utilising green space than either on the size of green space or on proximity. Understanding how all these attributes interact and translate into health outcomes is one direction for future research.

Interestingly, results of only two studies were based on objective health measurements (Michael et al. 2014 through clinical examination for detecting obesity; Richardson et al. 2017a using accelerometry for detecting physical activity). All other studies under review used secondary data from official statistics or data from health questionnaires where respondents reported their health status themselves, mostly through well-developed Likert scale measurements for perceived health. In the two studies using objective measures, no consistent association between health and urban green space was identified. One could argue that objectively measured health is the most reliable because it might be less biased by indirect indicators or perceptions. There are, however, other studies that use objective measures to assess potential links between stress levels and urban green space, e.g. through cortisol levels or electroencephalography (Ward Thompson et al. 2012; Aspinall et al. 2013). In these studies, stress levels were found to decrease in greener environments. Stress levels, however, always depend on many different aspects that may lead to an increase or decrease in stress levels. A combination of both subjective and objective measurements is an important field for future research.

Focus on the method of measurement is worth discussing here. All studies used and produced quantitative data and conducted statistical analyses. The review showed that important results were produced from this approach. No study in this review used qualitative research methods, such as an ethnographic approach that includes assessments of observing free behaviour. For children of a particular age group, Chawla (2015) pointed out that ethnographic approaches show how green space can contribute to the development of children's capabilities and to their "complete physical, mental and social well-being". Echoing Chawla (2015), future research should combine qualitative and quantitative approaches that include ethnographic assessment (see Kabisch and Haase 2014; Low 2013 for further details), but also experimental and correlational methods that, when used together, may increase the understanding of health and the environment.

The selection of particular search terms for the review has, of course, produced somewhat narrow results. Using other search terms may have contributed to a larger evidence base on the urban green space-health outcome association, e.g. through increasing the scope to other types of nature, such as trees. However, the focus of this review was to look at potential confounding factors that may explain health-outcome results, and to urban green spaces as a broad group of urban nature. Further, by limiting the review to recent studies, older studies are omitted, although they certainly are as important to review and discuss, especially as they relate to confounding variables.

5.5 Conclusion

Research studies on the association between urban green space and health shows that availability, proximity and use of urban green space such as parks or even allotment gardens, helps to improve the mental health of urban residents even when controlling for socio-economic or socio-demographic confounders. Studies that focus on other health outcomes, such as overweight or birth outcomes, show that significant relationships partly disappear when statistical models are adjusted for socio-economic variables. Income, deprivation or education are amongst the most important variables that confound the green space–health–outcome relationship. Nevertheless, a mediating role of urban green space for socio-economic inequality in health outcome was identified. The results have led to important planning recommendations and directions for future research, which have been presented and discussed here.

This area of research is gaining widespread attention through the promotion of the Sustainable Development Goals and related larger project financing, considering recent calls under the European Commission Research and Innovation Programme. A number of important studies are expected to be conducted in the near future.

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