

Green areas and health outcomes: a systematic review of the scientific literature

Francesco Di Nardo, Rosella Saulle, Giuseppe La Torre

Department of Public Health and Infectious Diseases, Sapienza University of Rome, Italy

Correspondence to: Giuseppe La Torre, Department of Public Health and Infectious Diseases Teaching Hospital "Umberto I" - 3rd Floor Radiology Building, University of Rome "Sapienza" Viale Regina Elena 324, 00161 Rome, Italy. E-mail: giuseppe.latorre@uniroma1.it

Abstract

Background: Growing medical evidence shows that access to the natural environment improves health and wellbeing, prevents disease and helps people recover from illness. Experiencing nature in the outdoors can help tackle obesity and coronary heart disease. Green areas exert their benefits on both physical and mental health, promoting physical activity and strengthening the sense of community thus positively influencing social interaction. Urbanization poses problems through effects such as environmental pollution, accidents, heat island effects, climate change and a consequent demand for urban green areas.

Material and methods: We performed literature searches of electronic journal databases for studies and reviews that focused on the relationship between green spaces and health. We looked at the effects on physical health, mental health, social health, physical activity and well-being in its broadest sense and then we categorically organized our findings.

Results: We found many contradictory and unexpected results. However, the reported findings were generally consistent and supported the current view that urban design and the availability of urban green spaces are key elements of prosperity and individual/collective comfort, so as to influence both the perceived health and the objective physical conditions in a measurable way. A weak relationship between physical activity levels and green space availability is observed.

Conclusions: The occasionally contradictory results that emerged in this study suggest that a population's response to urban design interventions is often unpredictable. Further research is needed to quantify the strength of relation between green spaces and urban health, but also to investigate the social and behavioural aspects which are more difficult to measure and understand.

Key words: green areas, health, well-being

Background

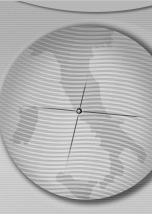
People are healthier and living longer if they live within an attractive natural environment. [1] Natural green space - our public parks, woodlands, countryside and even our tree lined streets - are an opportunity to improve health and reduce rates of 21st Century diseases. It has been suggested that people living closer to green open spaces are more physically active (through activities such as walking, jogging, cycling) and are less likely to be overweight or obese [2] as a result helping to combat rising levels of diseases, such as diabetes and heart disease. [3]

Studies also indicate that people living within natural environments and green spaces are less likely to fall ill due to depression, and natural green areas help people recover from chronic stress and concentrate better, [4-6] having positive effects on mental health. There

is growing evidence that the quality of our relationship with nature impacts on our mental health and many research studies have focused on how urban environments, with some nature elements, are associated with lower perceived stress and related to better mental health. Across processes that include social aggregation, this probably occurs due to the fact that the human body involuntarily reacts to natural elements somehow, whereas built environments seem not to provoke comparable reactions. [7, 8]

There's need to give more emphasis to researchers to find answers about the health benefits of contact with the natural environment, delivering health improvements to all communities.

Accordingly, good quality green space needs to be equally available to everyone in order to cancel the health gap. The availability of urban green spaces is an indicator given by the ratio between



the area of the municipality dedicated to urban green spaces and the resident population.

Since 2008, the majority of the human population lives in urban areas, an unprecedented occurrence in history, and in developed countries about 75% of their inhabitants living in dense urban areas. [9, 10]

Urbanization poses problems through effects such as environmental pollution, accidents, heat island effects, climate change and a consequent demand for urban green areas. [11, 12]. Green spaces contribute to regulate urban microclimate moderating the extreme temperatures, purifying and filtering air from dust and pollutants and reducing noise and vibrations. [13]

Green areas represent our natural health heritage for several human benefits, and their beneficial effects extend beyond being a cost-effective way of promoting health. Cost effectiveness, with substantial life-cost averted savings, and a high cost benefit ratio are brought about by increases in physical activity due to access to green areas.

Recent work has shown that where people have good perceived and/or actual access to green space they are 24% more likely to be physically active. *"If this effect was universal and the population of England was afforded equitable good access to green space, it is estimated that life-cost averted saving to the health service could be in order of £2.1 billion per annum."* [14]

So better health and wellbeing are two of the major social and economic benefits we can secure through good management of the natural environment in both rural and urban settings. The high costs of health care means there will be more emphasis on prevention rather than cure, encouraging people more interested in their own health [15] and National and international policy have to support the inclusion of the natural environment in holistic health promotion. [16]

Promoting health in urban populations necessarily involves a strategic leadership, focusing attention to multi-sectorial strategies leading to the rise of the 'Healthy Cities' movement [17, 18] and investing in programs for urban population (e.g. increasing green open areas, reducing traffic encouraging more walking and cycling movements).

Health Impact Assessment and Environmental Impact Assessment should always be integrated in urban planning approaches and therefore need to become essential parts of future strategies as well.

Methods

We performed literature searches of electronic journal databases for studies and reviews on

health effects of green spaces, according to PRISMA criteria. [19]

Databases searched were MEDLINE and SCOPUS. The keywords used were "green area", "green space", "population", "quality of life", "public health". Combined searches were carried out for: green area population quality of life; green space public health; "green area" AND "population" AND "quality of life"; "green space" AND "public health". The inclusion criteria were studies and review articles referring to green or public open spaces with a health perspective, limited to human studies and published in English. We excluded studies not pertaining to health and green areas or public open spaces or published before 2006. We looked at a health effect in its broadest sense to cover not just physical health but also mental health, social health, physical activity and well-being. This literature review was completed in October 2010. We also extracted information from the references of each study

Results

Identification of relevant research

We identified 361 records in the two databases. 278 records were available for screening after we removed the duplicates. 256 records were excluded because we judged them not suitable for the purposes of this study. 7 records were excluded because not relevant (Figure 1).

The 15 articles reviewed are shown in Table 1. Considering the study design, one review, one case-control study, 3 cohort studies and 8 cross-sectional studies were found.

Benefits on physical health

In their extensive review, Lee and Maheswaran noted that the availability of green space has been reported to be independently associated with increased survival in elderly populations and with lower stroke mortality. [13, 20, 21]

Many authors agree with these findings: in a wide interview, Stigsdotter et al. report that 82.1% of respondents living less than 300m from a green space declared that they had "really good" or "good" self-rated health compared with 72.4% among respondents living more than 1km from a green space. People living more than 1km away from the nearest green space had lower scores on the short-form health survey SF-36 and thus poorer health and health-related quality of life than those living closer than 1km from green spaces. [22]

The SF-36 is a 36-item instrument that measures eight dimensions of health (bodily pain; general health; mental health; physical functioning; role limitations due to emotional problems;

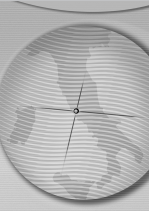
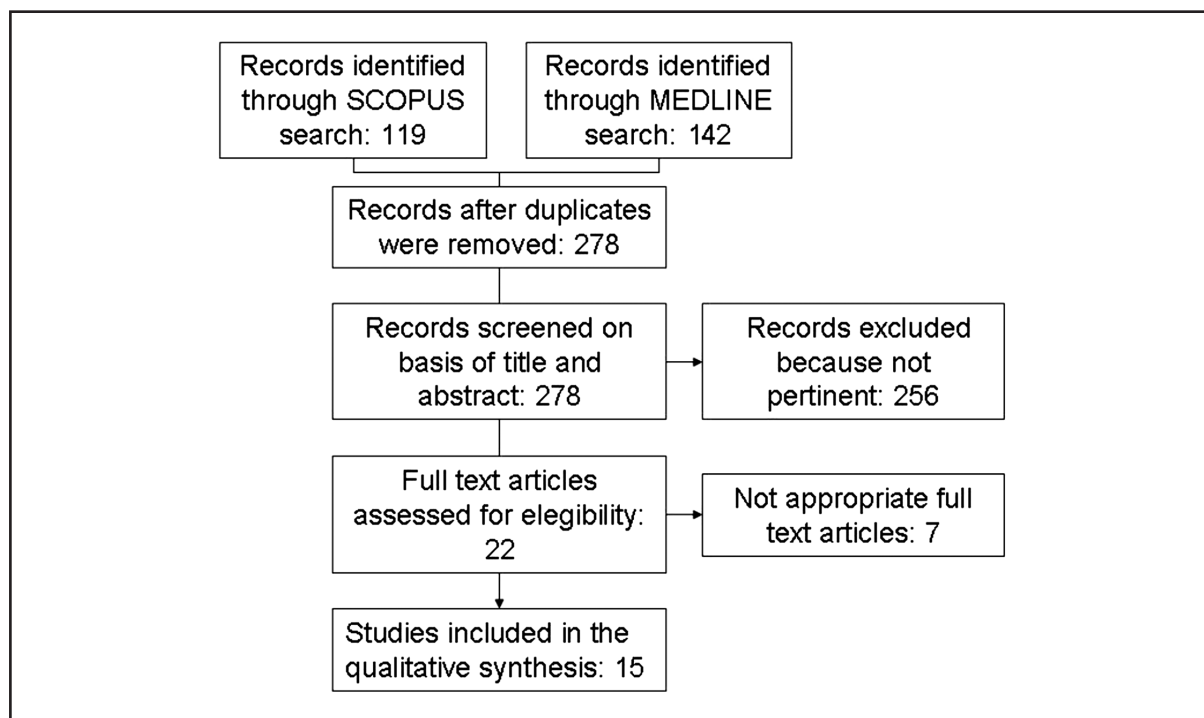


Figure 1. Study selection flow diagram.



role limitations due to physical health; social functioning; vitality) and was included in the self-administered questionnaire. [23, 24]

Data used in this study were derived from the 2005 health interview survey and based on a region-stratified random sample of 21832 adult Danes. [25]

Data were collected by means of face-to-face interviews in the respondent's home. In this study, all types of nature environments were grouped into one variable, called "green space".

Maas investigated the relationship between perceived health and different types of green space: according to her survey, in areas where 90% of the environment around the home is green, only 10.2% of the residents feel unhealthy, as compared with areas in which 10% of the environment is green, where 15.5% of the residents feel unhealthy. [26]

Moreover, her analysis showed that there seems to be a positive relationship between perceived general health and both agricultural green (1km: $\beta = 0.004$, $SE = 0.000$ /3km: $\beta = 0.004$, $SE = 0.001$) and natural green areas (1km: $\beta = 0.004$, $SE = 0.001$ /3km: $\beta = 0.006$, $SE = 0.001$) in a person's living environment. However, urban green within a 3km radius around the home seemed to be negatively related to people's health ($\beta = -0.008$, $SE = 0.002$), and this unexpected phenomenon, in the author's opinion, is probably caused by the fact that urban green can only be found in urban areas that have a lower total amount of

green space. Other findings were that people with secondary education level benefit most from green space and that people who are highly educated only benefit from green space in strong and moderate (only just significant within a 1km radius) urban areas. These analyses suggest that the lower educated groups are more sensitive to the characteristics of the physical environment.

When the effects of the amount of green space were analysed for different age groups in the different degrees of urbanity, it seemed that the relationship was most consistent for the elderly, who benefitted from green space in all urban areas. Only the elderly and the youth seemed to benefit from green space in strongly urban areas. [26]

Contrary to expectations, an observational study on a population of 1546405 living in 1009 small urban areas in New Zealand found no relationship between availability of total green space and cardio-vascular disease (CVD) mortality and no evidence that CVD mortality was inversely related to the availability of either total or usable green space, suggesting that the relationships between green space and health may vary according to national, societal or environmental contexts. [27]

In an observational study, conducted during 2003-2004 on 1895 participants living in urban areas of Adelaide, Australia, those who perceived their neighbourhoods to have the highest degree of greenness (the items included the following attributes: access to a park or nature reserve;

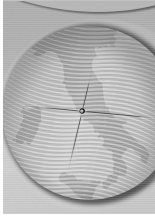
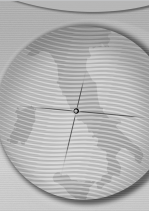


Table 1. List of studies in this review.

Author	Year	Study type	Sample	Main results
Lee & Maheswaran [5]	2010	Review	35 articles	It is difficult to establish a significant association between the availability of urban green spaces and both physical and mental health because of the complexity of this relationship and the bias, the weak statistical evidence and the confounding factors found in many articles. Usage of green areas for recreational physical activities depends on many determinants such as gender, age, individual motivation, personal barriers, lack of time, perceived safety, unpredictable weather, number of facilities and features, accessibility, maintenance and safety.
Stigsdotter et Al. [17]	2010	Cross-sectional study	21832 living in Denmark	People living less than 300m from a green space declare better perceived physical and mental health than people living more distant. People living more than 1km away from a green space have 1.42 higher odds of experiencing stress. People suffering from stress are likely to use green spaces to reduce stress.
Maas et Al. [21]	2006	Cross-sectional study	250782 living in The Netherlands	In areas with a higher percentage of green space people report better perceived health; lower educated groups are more sensitive to the physical environmental characteristics.
Richardson et Al. [22]	2010	Observational study (cohort study)	1546405 living in New Zealand	There is no significant relationship between availability of total green space and cardiovascular mortality.
Sugiyama et Al. [23]	2008	Observational study (case - control study)	1895 living in Australia	People who perceive their neighbourhoods to have the highest degree of greenness have 1.37 higher odds of reporting better physical health and 1.60 higher odds of reporting better mental health.
Richardson & Mitchell [26]	2010	Observational study (cohort study)	28600000 living in the United Kingdom	In areas with a higher percentage of green space the risk of death from cardiovascular and respiratory disease decreases for men but not for women.
van den Berg et Al. [31]	2010	Cross-sectional study	4529 living in Denmark	Access to green spaces positively affects stress and mental health. Green spaces provide as a buffer against stressful life events. This moderating effect was found for green space within 3km, but not for green space within 1km from home.
Guite et Al. [37]	2006	Cross-sectional study	2696 living in the United Kingdom	There are significant relations between poor mental health and neighbour noise, feeling over-crowded in the home and being dissatisfied with access to green open spaces; there are significant relations between poor vitality and poor access to community facilities and feeling unsafe to go out in the day.
Maas et Al. [44]	2009	Cross-sectional study	10089 living in The Netherlands	The availability of green spaces in the living environment is positively related to the feelings of loneliness and shortage of social support, especially for children, for the elderly, and for people with a lower economic status; feelings of loneliness and shortage of social support partially mediate the relation between green space and overall health.
Hillsdon et Al. [51]	2006	Cross-sectional study	4950 living in the United Kingdom	There is no evidence of significant relationships between recreational activity and access to green spaces.
Kaczynski et Al. [53]	2008	Observational study (cohort study)	380 living in Canada	Parks with more features were more likely to be used for physical activity and the availability of walkable paths has the strongest relationship with park use for physical activity purposes; size and distance are not significant predictors of a park being used for physical activity.
Cohen et Al. [54]	2006	Cross-sectional study	1556 living in the U.S.A. (only females)	Adolescent girls who live near more parks engage in 4%-6% extra nonschool metabolic equivalent-weighted moderate/vigorous physical activity. The relation between physical activity and green spaces is stronger for parks with amenities that are conducive to walking and with active features.
Jones & Hillsdon [55]	2010	Cross-sectional study	6821 living in the United Kingdom	Reported frequency of green space use declines with increasing distance of green spaces from home. People living closer to the type of green space classified as a "formal park" are more likely to achieve the physical activity recommendation and less likely to be overweight or obese.
Maas et Al. [56]	2008	Cross-sectional study	4899 living in The Netherlands	No relationship between the amount of green space in the living environment and whether or not people meet recommendations for physical activity. People living in a greener environment spend more time at cycling for commuting purposes and gardening.
Abercrombie et Al. [61]	2008	Cross-sectional study	833 census block groups in Maryland and Washington DC, U.S.A.	Mixed-race neighbourhoods have a higher number of parks, regardless of income. Low- and middle-income groups living in mostly-white block groups and high-income groups living in mostly-minority block groups have the lower access to public parks. Private facilities are inversely related to the percent of children in the block groups.



access to bicycle or walking paths; presence of greenery; presence of tree cover or canopy along footpaths and presence of pleasant natural features) had approximately 40% higher odds of belonging to the better physical health category (measured with the short-form health survey SF-12), compared with those who reported the lowest degree of greenness. [28, 29]

To identify the perceived greenness of a neighbourhood, five questions from the Neighbourhood Environment Walkability Scale were used. [30]

The level of association did not change substantially after controlling for age, education, work status, household income and marital status. After further adjusting for walking as a means of recreation, social coherence and local social interaction, the association between greenness and physical health became non-significant ($p=0.06$). In this model, recreational walking was a significant predictor of participants' physical health but neither social coherence nor local social interaction was associated with physical health. [28]

Richardson and Mitchell found gender differences when studying the relationships between urban green space and health. In their study, carried out in the UK, the risk of cardiovascular and respiratory disease mortality decreased with increasing green areas for males ($p < 0.001$), and was lowest for the greenest wards (cardiovascular disease: incidence rate ratio (IRR) 0.95, 95% CI 0.91-0.98; respiratory disease: IRR 0.89, 95% CI 0.83-0.96). Thus, males living in the greenest urban wards in the UK had a 5% lower risk of cardiovascular disease mortality and 11% lower risk of respiratory disease mortality than those in the least green wards. In contrast, no association with urban green space was found among females for cardiovascular and respiratory mortality. [31]

The authors considered the possibility that the lack of association between green space and cardiovascular disease and respiratory disease mortality for women might reflect the fact that women tend to die from these diseases at older ages than men.

Benefits on mental health

It's clear from Lee's review that physical and social features of the environment affect behaviour somehow. [13, 32]

Studies in different groups such as students, inner city girls, and workers reported associations between green space and several psychological, emotional and mental health benefits. [33, 34]

The possibility to access green spaces also positively affects stress and quality of life. [22, 35-37]

The presence of green vegetation and the formation of neighbourhood social ties in urban areas significantly contribute to residents' sense of safety and adjustment. [38]

However, much of the literature on the psychological benefits of green space tended to be qualitative or from grey literature sources, the quality of which varied. There is generally a lack of robust evidence for the link between mental health, well-being and green space but this may be due to the inherent difficulties in quantifying non-physical health benefits. [13]

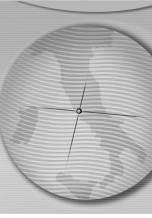
According to Stigsdotter's survey, respondents that more often visited green spaces reported less stress. Furthermore, the longer the distance of the respondents' homes from the nearest green space, the more stress was reported. The association between stress and distance to green spaces remained even after adjusting for potential confounders. As a result, Danes living more than 1km away from a green space resulted as having 1.42 higher odds of experiencing stress than those living less than 300m from a green space. [22]

An analysis of the association between stress and visits to green spaces showed that respondents who do not report stress have 1.57 (95% CI 1.40-1.76) higher odds of visiting a green space at least a few days a week than those reporting stress. The reasons for visiting green space differed significantly whether the respondents were stressed or not. A higher percentage of stressed respondents, compared to those not stressed, reported that the most important reasons for visiting green spaces were to "reduce stress/relax" and to "obtain peace and quiet without noise". The results also showed that the more often respondents visited green spaces, the less stress they experienced. [22]

These results are also in line with findings from previous studies. [28, 29]

Sugiyama et al. state that those who reported the highest degree of greenness in their survey had almost twice the odds of being in the better mental health category, compared with those who perceived little greenness in their neighbourhood. After adjusting for the socio-demographic variables, the strength of the association between the highest degree of greenness and mental health was attenuated but nonetheless remained significant. The amount of recreational walking undertaken and the social coherence were significant predictors of the mental health score. [28]

Recreational walking and social coherence were associated with mental health scores and perceived greenness remained an independent, significant predictor of mental health. This



suggests that the relationship between perceived greenness and mental health is not totally attributable to walking or to social cohesion. One potential factor explaining this “unaccounted” path may be the restorative effects of green or natural environments. The finding suggests that neighbourhood green spaces are conducive to better health, in so far as they are walkable, especially in the case of physical health. [28]

Other authors confirm that the availability of green or natural environments is associated with adults’ perceptions of better health. [26, 39-41]

In a study on 2696 adults living in wards with high levels of deprivation and with different range of environmental features in Greenwich, U.K., Guite et al. found significant relationships between poor mental health and: neighbour noise (OR 2.71, 95% CI 1.48, 4.98), feeling over-crowded in the home (OR 2.22, 95% CI 1.42, 3.48), being dissatisfied with access to green open spaces (OR 1.69, 95% CI 1.05, 2.74), confirming an association between the physical environment and mental well-being across a range of domains. [42]

These authors also found significant relationships between poor vitality and: poor access to community facilities (OR 1.92, 95% CI 1.24, 3.00), feeling unsafe to go out in the day (OR 1.58, 95% CI 1.00, 2.49). [42]

Selection of the wards was based on the ward Index of Multiple Deprivation. [43]

Measures to assess satisfaction with the physical environment were based on the five domains of Chu’s model. [44]

Mental health was measured by SF-36 version 2. [45-47]

Benefits on social health

Social capital is positively influenced by green spaces which provide a meeting place for users to develop and maintain neighbourhood social ties. [13, 38, 48, 49]

Social interaction enhances personal and social communication skills. [38, 50]

Moreover, it is also probable that exposure to green spaces may have an impact on urban socioeconomic health inequalities. [51]

However, studies found that inner city and poor populations are less likely to report participation in outdoor recreation activities. [50, 52]

Teenagers living in disadvantaged neighbourhoods, for example, lacked access to parks they considered safe and were therefore less likely to participate in physical activities than teens in more affluent neighbourhoods. [53]

Another study noted that people in low-income households were more likely to adopt low levels of activity and were least well served by affordable facilities. [54]

Wealthy residents, on the other hand, were more likely to live in close proximity to facilities of any type. [54]

Socioeconomic differentials in physical inactivity are consistent with socioeconomic gradients in many health outcomes and may represent a key pathway through which socioeconomic status affects health. [55]

The unequal distribution of green space could account for some of the cross-cultural and socioeconomic variations in their use. Even if access to green space appears to be implicitly linked with levels of deprivation, confounding factors such as individual lifestyles cannot be discounted since they could have socioeconomic links. [13]

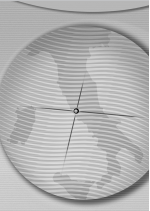
A study from Maas showed a relation between loneliness and distance from the closest green area in strongly urban municipalities. People with more green space within a 1km radius around their home experience less shortage of social support. This relation was apparent for children (in a 1 and 3km radius), young adults (1 and 3km), adults (3km), elderly (3km), lower educated people (1 and 3km) and people with a low income (1 and 3km). [49]

However, people experiencing less loneliness and shortage of social support did not have more contact with neighbours or friends in the neighbourhood and they didn’t receive more social support. This suggests that the relationship between green space and social contacts has more to do with the fact that green spaces can strengthen sense of community by means of place attachment and place identity of its residents, than with real contacts with neighbours. [49]

It is of notice that this author revealed how the feelings of loneliness and lack of social support appear to partially mediate the relationship between green space and self-perceived health (1km: $z = 6.26$, $p < 0.001$ / 3km: $z = 7.43$, $p < 0.001$), number of health complaints (1km: $z = -6.22$, $p < 0.001$ / 3km: $z = 7.36$, $p < 0.001$) and self-reported propensity to psychiatric morbidity (1km: $z = -5.57$, $p < 0.001$ / 3km: $z = 6.89$, $p < 0.001$). [49]

Physical activity and green space

From Lee and Maheswaran’s review, it is clear how the usage of green areas for recreational physical activities purposes depends on many user determinants. Factors such as gender (with males using parks more than females), age (negatively



affecting only the elder), high individual motivation (positive attitude towards the process of being physically active and partaking in physical activity with a significant other), personal barriers (with overweight people and people suffering from poor health or disabilities using parks less than others) and lack of time; perceived safety (affecting especially females) all appear to influence the use of green areas. [13]

Environmental determinants such as unpredictable weather (keeping people from using parks), number of facilities and features (being positively related to park usage), and accessibility (maintenance and safety) are important factors that also influence the level of physical activity and green space use. [13]

From a survey involving 4950 participants residing in the city of Norwich who completed a physical activity questionnaire it resulted that males had higher levels of recreational physical activity (mean of 8.43 h per week) compared with females (mean of 5.84 h per week) and this difference was statistically significant ($p < 0.001$). Participants aged 60–70 years were the most active age group (mean of 7.54 h activity per week). Those aged 40–50 reported a mean of 5.95 h of activity per week, those aged 50–60 reported a mean of 6.49 h per week and those aged 70 or over reported a mean of 7.34 h per week. In general, the older age groups were more active than the younger ones ($p < 0.001$). Significant, positive associations with recreational physical activity were also found for education ($p < 0.001$), Townsend Index ($p < 0.001$) and car ownership ($p < 0.001$). There was no significant relationship between recreational physical activity and self-reported health problems. [56]

Parks were evaluated with a tool containing 69 items grouped into eight themes as follows: accessibility, maintenance, recreational facilities, amenity provision, signage and lighting, landscape, usage, and atmosphere. Sixty-one green spaces in Norwich were surveyed using the tool. Unexpectedly, participants with the best access to high-quality large green spaces actually reported significantly lower levels of activity compared with those with the poorest access, suggesting that some factors not directly measured but related to local environments may be determinants of activity. Furthermore, the neighbourhood measures of access to green spaces showed non-significant associations with recreational physical activity. [56]

No studies have reported a positive association between access to green space and overall levels of physical activity, and one has even reported an inverse relationship. [57]

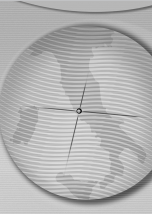
An observational study from Kaczynski et al. showed that only the number of features is a significant predictor of a park being used for physical activity (OR = 1.45; 95% CI = 1.09, 1.82; $p = 0.03$), while park size and distance to participants' homes didn't seem to play an important role and were not considered significant predictors. Parks that were used for physical activity had an average of 5.86 facilities and 6.57 amenities, compared with only 2.74 facilities and 4.00 amenities in parks that were not used for physical activity. [58]

The presence of paved trails (OR = 32.41; 95% CI = 3.27, 320.36; $p = 0.01$), unpaved trails (OR = 7.11; 95% CI = 1.40, 36.12; $p = 0.02$), and wooded areas (OR = 6.75; 95% CI = 1.40, 31.90; $p = 0.02$) were significantly related to park-based physical activity when examined independently. However, when they examined these 3 variables concurrently, only the presence of a paved trail was a significant predictor of some physical activity occurring within the park. Indeed, parks with a paved trail were almost 26 times more likely to be used for physical activity than parks without a paved trail (OR = 25.93; 95% CI = 2.15, 312.51; $p = 0.01$). [58]

A study including 1556 grade 6 girls from U.S. showed that the presence of parks was associated with higher levels of non-school metabolic equivalent-weighted moderate-to-vigorous physical activity (MEMVPA, a measure accounting for the volume and intensity of activity) among adolescent girls. It also suggested that this relationship holds for proximity, number, and the type of parks, as well as specific park amenities. [59]

The authors made girls wear accelerometers for 6 days to measure MEMVPA. Trained staff used a checklist to document the presence of facilities and amenities at each park, including passive amenities, such as drinking fountains, restrooms, and areas with shade, and active amenities like basketball courts, multipurpose fields, playgrounds, and tennis courts.

A study on 6821 adults examining the association between objectively measured access to green space, frequency of green space use, physical activity, and the probability of being overweight or obese in the city of Bristol, England, showed that people living further from urban green spaces were less likely to visit them than those nearby, and this effect was particularly strong for formal green spaces. Respondents living further from green spaces were also less likely to meet guideline physical activity levels and more likely to be overweight or obese, even after adjustment for the walkability of respondent's neighbourhoods, their



socioeconomic status, and area deprivation. [60]

Some disparities became apparent during the examination of access by green space type: mean distances were 2207m for young people's green areas, 1758m for formal, 1082m for sports, 570m for natural, and 481m for informal green space types. About 30% of respondents lived within 300m of informal and natural green spaces, but only less than 10% lived within 300m of young people's and sports green spaces. [60]

Maas et al. investigated whether physical activity (in general but also, in particular, walking and cycling during leisure time and for commuting purposes, sports and gardening) is an underlying mechanism in the relationship between the amount of green space in people's direct living environment and self-perceived health. They found no significant relationship between the percentage of green space and meeting the public health recommendations for physical activity. Quite surprisingly, findings show that people walk less often during leisure time when there is more green space in their direct living environment. This relationship is as large in a 1km radius as in a 3km radius around one's home. They also showed that people spend less leisure time on walking when there is more green space in a 3km radius around their home. People with 20% green space in a 3km radius around their home walked approximately 250 minutes per week for leisure, whereas people with 80% green space in a 3km radius around their home walked approximately 190 minutes per week during leisure time. [61]

There is also a negative relationship between the percentage of green space in a 1km radius around the living environment and whether or not people cycle during leisure time.

There is no significant relationship between the percentage of green space and walking for commuting purposes: people with more green space around their homes do not walk more often for commuting purposes and do not walk for commuting purposes for a longer period. However, Authors observed an effect in people cycling for commuting purposes: they were likely to spend more time on it if they had a higher percentage of green space in their living environment, and this was apparent both in a 1km and 3km radius. People with 20% green space in a 1km radius around their home cycle approximately 120 minutes per week for commuting purposes, while people with 80% green space in a 1km radius around their home cycle approximately 170 minutes per week for commuting purposes. [61]

People with a higher percentage of green space in a 1km radius around their home also garden

more often: people with 20% green space in a 1km radius around the home garden approximately 180 minutes per week, whereas people with 80% green space in a 1km radius around their home garden 265 minutes per week. [61]

In the authors' opinion, the finding that people with more green space in their living environment less often walk or cycle is probably due to the fact that in greener living environments, facilities are further away and people more often use a car to reach them. Furthermore, green spaces are usually more available outside the strongly urban areas, where the chances of parking a car near home are much higher.

Despite the well documented health disparities showing how low-income populations and those from ethnic and racial minority groups have shorter life spans, higher rates of chronic diseases, less access to (and lower quality of) health care and lower quality of life than wealthy and non-Hispanic white populations, income and racial disparities don't affect access to public parks in the U.S., as confirmed by Abercrombie et al. who reported that the expected deprivation of recreation facilities in low-income and high-minority areas was not found in their study for private or public facilities. [62-66]

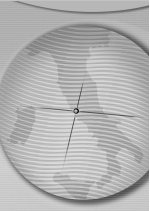
Authors expected private companies to concentrate in areas where ability to pay is better, but their results weren't totally surprising: other studies conducted in Scotland and Australia found even greater access to recreation resources in disadvantaged communities. [67, 68]

Number and size of parks were positively related to the percent of children in the block group, suggesting that park placement decisions were somewhat sensitive to providing access to children. The possibility that families with children may choose to move near parks shouldn't be miscalculated. However, the number of private facilities resulted to be inversely related to the percent of children in the block group, indicating that business decisions won't serve children properly. [66]

Discussion

In our review of the most updated literature regarding the relationships between green spaces and wellness, we found many contradictory and unexpected results. That said, the reported findings in studies were generally consistent and supported the current view that urban design and the availability of urban green spaces are main elements of prosperity and individual/collective comfort, so as to influence both the perceived health and the objective physical conditions in a measurable way.

At any rate, establishing a causal relationship



between green spaces and health was difficult and reviews done so far have often been based on contradictory or weak studies. Even after socioeconomic factors are controlled for, the possibility of confounding factors cannot be excluded. [13]

Overall, people with more green space in their living environment feel healthier, experience a lower number of health complaints and have lower self-rated propensity for psychiatric morbidity. [14, 49]

Even if the relationship between green spaces and physical health is often hard to prove, since it is necessary to identify phenomena which exert their effects over long periods of time, we can safely state that male cardiovascular disease and respiratory disease mortality rates decrease with increasing green space, but no significant associations were found for women. [31]

On the other hand, it isn't much easier to measure the effects that green spaces have on mental health, given that data are usually self-reported and not quantitative. However, we found strong associations between the physical environment and mental well-being across a wide range of domains.

The Literature provides evidence for an association between health-related quality of life and distance from one's private home to the nearest green space and also supports a positive association between use of green spaces and relief from stress: the more often people visit green spaces, the less stress they experience. [13, 28, 42]

Additionally, our findings suggest that the longer the distance one's home is from the nearest green space, the more stress people experience. [28, 42]

In line with this, the reasons for visiting green spaces differ significantly depending on whether or not people experience stress: subjects reporting stress state reasons for visiting green spaces that are connected to mental restoration, while those not affected from stress mostly demand physical challenges and mental strength. [13, 28, 42]

The most important factors operating independently on mental health appear to be neighbourhood noise, sense of over-crowding in the home, sense of overcrowding in the escape facilities like green spaces and community facilities, and fear of crime. [13, 36, 39]

Not only does the availability of green spaces positively affect the levels of stress, but people actively seek for nature when stressed also. A bright (though dramatic) example is provided by Lazaroff, who reported a marked increase in the number of visits of green spaces following the attacks on the World Trade Centre in 2001,

according to the national parks authorities. [69]

As said, a growing number of studies show that contacts with nature have beneficial mental health effects. Research has found strong evidence for a positive relationship between exposure to nature and restoration from stress and attention fatigue, but studies have also shown that green spaces have indirect effects on mental well being like serving as a buffer against the health impacts of stressful life events. [36]

A buffer is a moderating variable decreasing the association between an independent variable and an outcome variable and explains in which way or under which conditions the independent variable affects the outcome variable.

At the same time, as we observed that feelings of loneliness and shortage of social support partially mediate the relationship between green space and overall health, it appears evident that the amount of green space in the living environment is positively related to the feelings of loneliness and shortage of social support, especially for children, for the elderly, and for people with a lower economic status, affecting both the individual well-being and the entire social order by means of improving attachment and social coherence. [42, 49]

Regarding physical activity, common sense may suggest an association with the availability of green spaces but, from the literature, the evidence for the link between physical activity levels and green space availability appears to be weak or less clear-cut, while there is strong evidence of the health benefits deriving from physical activity. [13, 58-61]

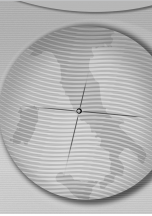
It has been estimated that physical inactivity causes 1.9 million deaths globally each year. [70]

Adults don't reach the recommended level of physical activity, which is at least 30 minutes of moderate activity on five or more days per week. [70-72]

Even though several studies support the view that green spaces promote physical activity, offering opportunities for valuable exercise such as walking and cycling, further studies are needed to evaluate the nature of these significant relationships. Green spaces may affect people's attitude towards physical activity in other ways, although these mechanisms are not always clear. [58-61]

Further research is needed to quantify the strength of association between green spaces and urban health, but also to investigate the psychosocial and economic dimensions that are more difficult to measure. [22]

Moreover, we have to recognise that detailed scientific knowledge is important and needed



to implement environmental programs with the overall aim of protecting the human population from environmental related diseases. [73]

In this context, there is increasing evidence on the functional role of urban green to monitor and improve urban air quality - even with the use of Geographical Information System (GIS) that in recent years has been in widespread use for public health purposes - and, as a direct consequence, quality of life in populations in urban areas. [74, 75]

Limitations of this study

The occasionally contradictory results of this study prove that a populations' response to urban

design interventions is often unpredictable. Many unexpected results probably occurred because of the differences in population habits, geographical locations, measures and definitions of green space as well as self-report measures of "well-being".

Many studies presented in this review- focusing on physical health outcomes- deal with perceived rather than objective health conditions documented, thus limiting our capability to evaluate the real impact that green spaces have on health.

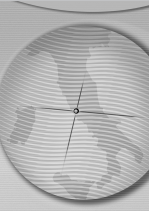
Measuring the real amount of physical activity is complex and often neglected. Self-reported data might be unreliable, since informal physical activity is also an important component of the overall activity levels.

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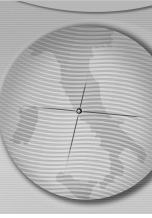
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