Van den Berg, A. E., & van den Berg, M. M. H. E. (2015). Health benefits of plants and green space: establishing the evidence base. *Acta Horticulturae* 1093,19-30.

Health Benefits of Plants and Green Space: Establishing the Evidence Base

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Keywords: Human issues in horticulture, landscape, people-plant interaction, pyramid of evidence, response to nature, green space and health.

ABSTRACT

Among the many benefits provided by plants, "health" stands out as a benefit that is especially highly valued. Over the past decades, people-plant studies have increasingly focused on empirically demonstrating relationships between plants and health. However, there are as yet no consensual standards in the field as to which research findings qualify as evidence for health benefits of plants. In this paper, we first argue that only studies that directly relate exposure to plants and green spaces to health outcomes should be admitted into the evidence base. We then discuss several studies that meet this requirement. An important conclusion is that the experimental evidence base for health benefits of plants seems to be less strong than the evidence provided by observational population studies linking green spaces to public health. Consequently, observational studies deserve more attention from horticultural professionals and other audiences who share an interest in health benefits of plants. However, as living in green areas is often accompanied by certain conditions and lifestyles that promote health, there is still an urgent need for more rigorous studies that allow for a causal interpretation of health effects of plants and green spaces.

INTRODUCTION

Plants provide a myriad of benefits to people, from the provision of food, fibers and building materials to more intangible benefits such aesthetic pleasure and improvement of health (Lohr, 2011). These benefits may occur not only with individual plants, but also with natural environments or "green spaces" such as gardens, parks, forests and other natural settings. Among the benefits provided by plants, "health" stands out as a benefit that is especially highly valued in modern society. Health is generally considered the most valuable asset in life (Schwartz, 1992). Unfortunately, in many parts of the world, this asset is threatened by developments related to aging populations and unhealthy lifestyles. To relieve the healthcare burden that derives from these developments, governments and other health authorities are actively seeking new ways to prevent disease and promote health. Plants have long since been associated with healing powers, and there is a long tradition of the use of plants for medical purposes. Plants therefore provide a potentially powerful means to relieve the healthcare burden of an aging and increasingly unfit population in nations worldwide.

There is a growing awareness and recognition by individuals from many different professions of the value of scientific evidence for health benefits of plants and green spaces. This evidence can support policy makers and other key community and health decision makers in making well-informed decisions on the use of plants and green spaces that optimize the benefits for the community. In addition, evidence can yield practical guidelines for horticultural therapy and other interventions that make use of health benefits of plants and green spaces. In this paper, we sketch a first outline of the main features of an evidence base for health benefits of plants, including criteria for the inclusion of studies and grading of the evidence. We also provide an overview of currently available evidence for direct health benefits of plants from studies with different experimental and observational research designs. In this overview, special attention is paid to the evidence provided by observational studies of relationships between green space and health at the population level. Because publications of these studies have been scattered across different medical and public health journals, this literature has thus far been relatively inaccessible to horticultural professionals and other audiences who share an interest in plants and nature. The paper concludes with a discussion of the strengths and limitations of the current evidence base for health benefits of plants and green spaces, along with suggestions for future research.

WHAT QUALIFIES AS EVIDENCE?

To date, there are no consensual standards in the field of people-plant studies as to which research findings qualify as evidence for health benefits of plants. In general, the term "evidence" is used in a very loose manner and the bar for what qualifies as evidence is set very low.

Following standard guidelines for the evaluation of health research, we propose three basic criteria for inclusion of research in the evidence base for the effectiveness of plants and green spaces to improve health (National Institute for Health and Clinical Excellence, 2009).

1. Use of health outcome measures. As a basic rule, only studies that have measured health outcomes qualify for inclusion into the evidence base for health benefits of plants. But what constitutes a health measure? Unfortunately, there is not yet a shared understanding in the field of people-plant studies of what constitutes a health outcome. The concept of health is typically very broadly interpreted, including not only direct measures of physical and mental health, but also health-related outcomes such as physical activity, stress or air quality.

In general, two types of health outcome measures can be distinguished (College of Emergency Medicine UK., 2012; Van den Berg et al., 2012). First, clinical and patient centered health outcome measures cover objective and subjective measures of patient functioning, such as symptom severity, mortality, hospital days, medication use, discomfort (pain, nausea), physiological responses, and patient satisfaction. Second, public health measures give an indication of the health status of a population. These indicators include measures based on birth and death statistics, such as mortality rates and life expectancy, measures of the prevalence and incidence of disease and illness (also called morbidity rates), measures of self-reported general, mental and physical health, and measures of health-related quality of life.

2. Focus on exposure to plants and green spaces. A second criterion is that health outcomes must be directly linked to the exposure variable of interest, i.e. plants and other natural elements and settings. A major implication of this criterion is that evaluations of nature-assisted therapies, such as horticultural or wilderness programs, are excluded from the evidence base for health benefits of plants unless they include a control group that receives a non-natural intervention that is identical to the nature-based intervention except for the exposure to plants or green space. In a similar way, population studies that link green space to

health do not count as evidence for health benefits of plants unless they use some form of statistical control to disentangle the influences of green space from other variables that typically co-occur with the presence of green space, such as the higher socio-economic status of greener neighborhoods. In general, only studies that tap into the unique contribution of plants and green spaces to health outcomes qualify as evidence for health benefits of plants.

A much-debated issue in the literature on people-plant relationships is whether exposure to "plastic plants" and other imitations of nature (e.g., photos or videos of natural landscapes) provides a valid way to study health benefits of plants and green spaces (De Kort et al., 2006). As yet only few studies have compared people's (psychophysiological) responses to real and virtual nature, with somewhat mixed findings (Kahn et al., 2008; Felsten, 2009; Kjellgren and Buhrkall, 2010). Therefore, we suggest to exclude studies using photos and other simulations of plants and green space from the evidence base for health benefits of plants and green spaces, unless more evidence for the validity of such studies should become available.

3. Comparison of health outcomes over time and/or across locations. A third basic inclusion criterion is that a study should compare health outcomes over time, e.g. by means of pre- and post intervention measures, or across locations that differ in the presence of plants or green space. Following this criterion, opinion surveys, post-occupancy evaluation studies, focus groups or other non-comparative studies do not qualify as evidence for health benefits of plants. This is not to imply that such studies cannot convey useful information on the use of plants for health purposes, only that this information does not count as evidence for the effectiveness of plants to promote health or prevent or cure disease.

The above three criteria only outline the minimum requirements for the admission of studies into the evidence base for health benefits of plants. Additional criteria, such as publication in a peer-reviewed journal may be set to increase the strength of the evidence base. However, given the limited availability of studies, it seems premature to set stringent inclusion criteria. Instead, the most pressing issue is to establish consensual guidelines for separating relevant from non-relevant research findings.

GRADING THE EVIDENCE

Studies that merit inclusion into the evidence for health benefits of plants may vary significantly in research method or design and the strength of the evidence provided. In general, research studies can be broadly classified as experimental or observational. In experimental studies, the investigator controls the assignment of participants to a ("green") intervention or exposure, which is often but not always performed randomly. In observational studies, the investigator "observes" phenomena or outcomes in general or specific populations without specifically assigning an intervention or treatment. Experimental study designs are generally considered to provide stronger evidence than observational designs, but this applies only when the experiment includes a control group that is not exposed to the intervention or treatment of interest. Uncontrolled experiments or intervention studies provide weaker evidence than most observational studies, except for case series that observe the medical histories of single patient or exposure groups.

The hierarchy in the strength of evidence provided by different study designs can be graphically represented as a pyramid, with the weakest (uncontrolled) designs residing at the bottom and the strongest (controlled) designs residing at the top. Figure 1 gives an example of a pyramid with six levels of evidence that apply to research on health benefits of nature. This pyramid presents only a summary and simplification of all the study designs that are available for studying health benefits of nature. For more detailed classifications, see Ho et al. (2008) and The National Institute for Health and Clinical Excellence (2009).

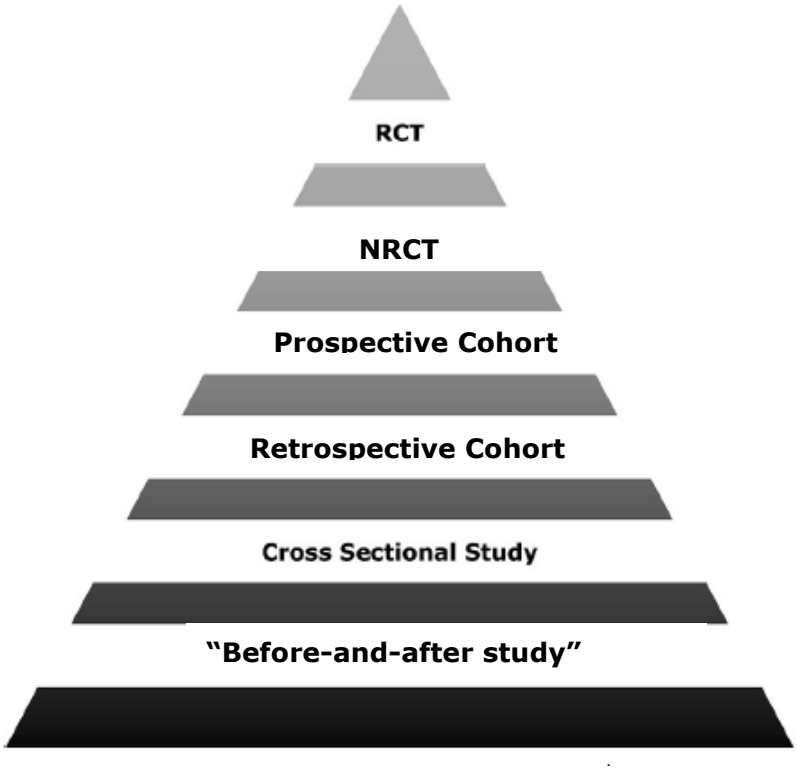

Figure 1. Pyramid of evidence. RCT = Randomized Controlled Trial; NRCT = Non-Randomized Controlled Trial

The bottom level of the pyramid is formed by "before-and-after studies" that measure health outcomes before and after a green intervention or exposure. For example, Raanaas, Patil and Hartig (2010) investigated the effects of a 4-week indoor plant intervention on self-report measures of health, well-being and emotion in coronary and pulmonary patients before, during, and after the intervention. Due to the lack of a control group it is not possible to determine whether any effects observed are due to the plants or to other causes such as general distraction or spontaneous recovery of the patients. Before-and-after studies therefore generally provide weak evidence of causality.

The next three steps up the pyramid consist of controlled observational studies. First, in cross-sectional studies, both exposures and outcomes are measured at a single point in time, and the prevalence of the outcome is compared among those with and without exposure to plants and green spaces. For example, Maas Verheij, Groenewegen, De Vries, & Spreeuwenberg (2006) showed that the amount of green space in residential neighborhoods is related to self-reported health of residents of these neighborhoods. Because attractive, green neighborhoods tend to attract wealthier and thus healthier people, cross-sectional studies typically use some form of statistical control for the influence of socio-economic background variables. However, causal influences of green space on health cannot be established with cross-sectional methods because self-selection cannot be completely ruled out.

Cohort or longitudinal studies provide a more rigorous type of epidemiological studies in which groups of people are followed (retrospectively or prospectively) over time to identify potential risk or preventive factors for certain diseases or outcomes. Because events are measured in a temporal sequence, causes can be more easily distinguished from effects. For

example a retrospective cohort study by Bell and colleauges (2008) found that economically disadvantaged children and youth in greener settings were less likely to increase their BMI scores over two years compared to their counterparts in less green neighborhoods.

At the top levels of the pyramid we find the controlled experimental studies. In these types of studies, the investigator assigns participants to (green) experimental and (non-green) control conditions. If participants are assigned by chance, the experiment is classified as a "randomized controlled trial", the "gold standard" of medical research. Using chance to assign people to conditions that differ on selected variables means that the groups will be similar and that causal inferences can be drawn on the influence of the variables. For example, Park and Mattson (2008, 2009) found that patients who were randomly assigned to recovery in hospital rooms with ornamental plants displayed better medical and psychological responses than patients in similar rooms without plants. Despite their significant strength, controlled experimental studies also have important limitations. They are typically expensive, time consuming, and designed to answer questions about the effectiveness of a specific intervention for specific groups. Thus, controlled experiments are usually very narrow in scope and may be inappropriate to address questions on the often long and complicated causal chains in general populations (Victora et al., 2004).

In the next two paragraphs, we will summarize the currently available evidence for direct health benefits of plants and green spaces from experimental and observational studies. This summary is not a comprehensive review. It highlights some of the studies that meet the criteria outlined above and it is mainly intended to give an impression of the size and strength of the evidence base.

EVIDENCE FROM EXPERIMENTAL STUDIES

Experimental evidence for health benefits of plants and green space mainly comes from two lines of research: (1) evaluations of the effects of horticultural and other nature-assisted therapies (e.g., gardening and wilderness programs) in various patient groups (see for reviews Elings, 2006; Annerstedt and Währborg, 2011), and (2) controlled laboratory or field experiments in which healthy participants are exposed to natural or built settings (see for reviews Van den Berg, 2005; Bowler et al., 2010). Both lines of research have typically reported findings that support the relevance of nature as a resource for health and well-being. However, following the criteria outlined above, these findings do not qualify as direct evidence for health benefits of nature. Evaluations of nature-assisted therapies typically include no control group, or only a passive control group that receives no therapy. Consequently, the effects of the therapy cannot be disentangled from the effects of other variables, such as individual counseling and group activities, and thus do not provide direct evidence for a link between plants and health. Controlled laboratory and field experiments provide more direct, causal evidence for positive effects of plants and green spaces on healthy individuals. However, most of these studies have used health-related outcome variables such as physical activity levels (Thompson Coon et al., 2011) or psycho-physiological responses (Van den Berg et al., 2007; Bringslimark et al., 2009; Park et al., 2010) instead of direct health outcome measures. Therefore, this line of research also provides only indirect evidence for health benefits of plants.

Only a few random controlled trials in patient populations provide direct evidence for health benefits of plants and green space. Among these studies is a series of clinical trials in which patients were randomly assigned to rooms with and without potted plants after thyroidectomy, appendectomy, or hemorrhoidectomy surgery (Park and Mattson, 2008, 2009). These trials show, among other things, that patients in rooms with plants have shorter hospital stays and need fewer intakes of postoperative pain medication than patients in rooms

without plants. A longitudinal study in a Norwegian rehabilitation center examined the health benefits of bedroom views of nature among coronary and pulmonary patients (Raanaas et al., 2012). Patients were quasi-randomly assigned to rooms with an unobstructed view onto mountains and a valley, or to rooms with only a partial view to nature or a fully blocked view that was dominated by buildings. The results show that an unobstructed natural view positively affected the mental health of men and the physical health of women. In addition, pulmonary patients with an unobstructed natural view showed greater improvement in mental health than coronary patients with such a view.

Outside the health-care setting, a random cross-over trial among children diagnosed with ADHD revealed that the children perform better on an attention test after a 20-minute guided walk in a park than after a walk in a more urban downtown or residential neighborhood (Faber Taylor and Kuo, 2009). Another random cross-over trial demonstrated that individuals diagnosed with major depressive disorder display better cognitive and emotional functioning after walking in a park than after walking in a built setting (Berman et al., 2012). Furthermore, a longitudinal cross-over study among healthy office workers in Norway revealed a 23 percent decrease in symptoms such as coughing or a horse throat during periods when foliage plants were added to their offices (Fjeld et al., 1998).

Summary

In sum, although many experimental studies have demonstrated positive effects of plants and green spaces on people, only few of these studies provide strong and direct evidence for health benefits of plants. Consequently, observational studies could make an important contribution to the evidence base for health benefits of plants.

EVIDENCE FROM OBSERVATIONAL STUDIES

In the early 2000's, research groups in the Netherlands (De Vries et al., 2003) and Japan (Takano et al., 2002) demonstrated for the first time direct relationships between green space in the living environment and public health. In the Dutch cross-sectional study, data on three health outcomes (perceived general health, mental health and number of health complaints) from a random sample of more than 10,000 people were linked to land-use data on the amount of green space in their living environment. Results show that, after controlling for socioeconomic and demographic characteristics, residents with a high percentage of green space in a 1 or 3 km radius around their home reported better general and mental health and fewer health complaints than those with a low percentage of green space around their home. Relationships between green space and health were stronger among lower socioeconomic status groups, the elderly, and others who stay home during the day, suggesting that the impact of green space on health is related to the amount of exposure to the local environment.

Takano et al. (2002) examined the five year survival rate of a cohort of more than 3000 seniors living in a highly urbanized area of Tokyo. They found a significant association with the self-reported amount of walkable green streets and spaces near the residence: older people who perceived their neighborhood as greener and easier to walk in lived longer (13 % higher odds for survival) independent of age, sex, social economic status and other potential confounders.

In the past ten years, the findings of these pioneering studies have been replicated and extended in different countries with various objective and self-reported indicators of green space and health. Thus far, however, this emerging literature has not received much attention in the field of people-plant studies. Below, we will discuss some of the key studies and their findings.

The Vitamin G Research Program

The initial publication of the Dutch research group (De Vries et al., 2003) has been followed up by a series of cross-sectional studies that were conducted as part of the large-scale Vitamin G (where G stands for Green) program in the Netherlands (for overviews of this program, see Groenewegen et al., 2006; Groenewegen et al., 2012). In one of these studies, the Vitamin G team looked at people's health as assessed by doctors (Maas et al., 2009b). Among other things, they found that having more green space within a one-kilometer radius of the home is linked to a reduced risk of depressive symptoms and anxiety. For another study, the Vitamin G team visited 80 Dutch neighborhoods to collect primary data on residents' health and green space quantity and quality indicators such as absence of litter, accessibility, and colorfulness (Van Dillen et al., 2011). Results show that people's self-reported general and mental health is positively related to both the quantity and the quality of the green space around their homes. In addition to the Vitamin G research program, many other observational studies have been carried out in different countries. These studies can be roughly divided into three groups according to the principal health outcome: general health outcomes, specific health outcomes, and mortality rates (Van den Berg and Maas, 2012).

Green space and general health

Using census data for the entire population, a cross-sectional study in the UK showed that a higher proportion of green space in an area is associated with better population health, especially in suburban lower income areas (Mitchell and Popham, 2007). A recent longitudinal study in the UK demonstrated that moving to greener urban areas was associated with sustained mental health improvements in all three postmove years (Alcock et al., 2013). Other cross-sectional as well as longitudinal UK studies have found that individuals report significantly better general health and mental health when living nearer the coast (Wheeler et al., 2012; White et al., 2013). These latter findings indicate that health benefits are not exclusive to "green spaces", but may also occur with "blue spaces".

A cross-sectional study in Australia showed that residents who perceive their neighborhood as highly green have better odds of physical and mental health compared with those who perceive it as not so green (Sugiyama et al., 2008). Another cross-sectional study in Denmark revealed relationships between distance to green space and health and health-related quality of life (Stigsdotter et al., 2010). A study in 75 neighborhoods in the city of Amsterdam, the Netherlands, showed that dissatisfaction with neighborhood green space was associated with a higher risk of fair to poor self-rated health (Agyemang et al., 2007). A comparative study in a "green" and "grey neighborhood in Belgium with similar socio-demographic, housing and spatial conditions found that residents of the green neighborhood reported higher levels of general health, bodily functioning and happiness. However, only the difference in happiness was significant (Van Herzele and De Vries, 2011). A Norwegian study examined relationships between indoor plants and health using cross-sectional survey data from 385 office workers (Bringslimark et al., 2007). After controlling for gender, age, and other factors the number of indoor plants proximal to a worker's desk was significantly related to reduced sick leave.

Green space and specific health outcomes

A cross-sectional study in the U.S. showed lower asthma prevalence among children living in areas with more street trees (Lovasi et al., 2008). Several studies in the U.S. and Spain have found a reduced risk of adverse pregnancy outcomes such as low birth weight in greener residential areas, especially among mothers with lower education (Donovan et al., 2011; Dadvand et al., 2012a; Dadvand et al., 2012b). In Australia, access to green public open

spaces was found to be associated with a more healthy cardiometabolic profile (Paquet et al., 2013)

Green space and mortality

Mitchell and Popham (2008) obtained mortality records of all deaths registered in England from the working-age population in a 5-year period. After adjustment for potential confounders and area-level income-deprivation index, they found that mortality rates decreased as the greenness of an area increased. Thus, residents of greener areas had a lower risk of dying before their retirement age. The relationship between mortality and green space was stronger for lower-income areas, suggesting that the provision of green space can reduce income-related health inequalities. Another study by the same research group observed significantly lower risk of all-cause mortality (excluding external causes) in small urban areas with more than 60% green space (Mitchell et al., 2011).

A recent study in New Zealand found no association between green space and 10-year mortality rates (Richardson et al., 2010). Another study by Richardson and colleagues, conducted in the U.S., found that mortality from all causes was even higher in greener areas (Richardson et. al, 2012). This study was performed at the geographical scale of whole cities with a total population of 43 million people. The authors of both studies argue that their results are country-specific: the variation in green space availability in New Zealand may be too small to find a relation and in the U.S. greater car-dependency related to urban sprawl as compared to West-European countries may obscure the potential health benefits of green spaces.

Summary

In sum, observational - mostly cross-sectional studies - indicate that access to plants and green spaces may promote health and protect people from the negative health consequences of living in poverty. However, to gain more insight into the causality of the relationships, there is a need for more rigorous, prospective study designs that follow large numbers of people with different exposures to green space over longer periods of time. To obtain a more balanced picture of both the positive and negative impacts of plants on health, future studies should also allow for the detection of possible health risks of plants and green space, such as the development of allergies due to sensitization to pollens and other natural substances (Cariñanos and Casares-Porcel, 2011).

CONCLUSION AND SUGGESTIONS FOR ADVANCING THE EVIDENCE BASE

In this paper we have outlined the evidence base for health benefits of plants and green spaces. We have argued that only studies that speak directly to a relationship between plants and health should qualify as evidence for health benefits of plants, and we have proposed some basic criteria for inclusion and grading of evidence. We have also highlighted some of the currently available evidence for health benefits of plants from studies with experimental and observational designs. An important conclusion is that the experimental evidence base for health benefits of nature does not seem to be very strong. Although experimental research has generally demonstrated positive effects of plants and nature-based activities on people, only few of studies have employed proper designs and measures that enable the identification of a direct link between plants and health. In the past ten years, an increasing number of observational studies have provided important complementary evidence for health benefits of plants at the population level. However, as living in green areas is often accompanied by certain conditions and lifestyles that promote health, there is still an urgent need for more

rigorous studies that allow for a causal interpretation of health effects of plants and green spaces.

To advance the evidence base for health benefits of plants, we propose three potential research directions. First, there currently exists a large body of experimental studies on nature-assisted therapy and restorative effects of nature that only indirectly provides evidence for health benefits of nature. By implementing some changes in the study design, future studies in these domains would qualify more directly for inclusion in the evidence base. For example, evaluations of nature-assisted therapies could include control groups that receive a non-nature therapy, or experimental studies on restorative effects of viewing or visiting nature could more often use patient samples instead of healthy volunteers. In general, when designing an experiment, investigators should become more aware of the potential relevance of their study to the evidence base for health benefits of plants and green spaces.

A second direction for future research pertains to the need for more rigorous prospective designs to assess the long-term health effects of exposure to plants to support well-informed decisions on the use of plants and green spaces in public health policy and practice. Finally, there is still little evidence on the mechanisms underlying relationships between plants and health. While many studies have demonstrated links between green space and possible mechanisms, such as stress, physical activity or social cohesion, only few studies have conducted mediational analyses to determine whether these mechanisms can explain relationships between green space and health (see for example Maas et al., 2008; Maas et al., 2009a; Van Herzele and De Vries, 2011). Conducting more of these studies can lead to a better understanding of the pathways by which plants may lead to better health, which can be used to optimize the use of plants and green spaces for the benefits of the community.

Literature Cited

Agyemang, C., Van Hooijdonk, C., Wendel-Vos, W., Lindeman, E., Stronks, K., Droomers, M. 2007. The association of neighbourhood psychosocial stressors and self-rated health in Amsterdam, The Netherlands. J. Epidemiol. Commun. H. 61:1042-1049.

Alcock, I., White, M.P., Wheeler, B.W., Fleming, L.E., Depledge, M.H. 2013. Longitudinal effects on mental health of moving to greener and less green urban areas. Environ. Sci. Technol. 48:1247-1255.

Annerstedt, M., Währborg, P. 2011. Nature-assisted therapy: Systematic review of controlled and observational studies. Scand. J. Public Healt. 39:371-388.

Bell, J.F., Wilson, J.S., Liu, G.C. 2008. Neighborhood greenness and 2-year changes in body mass index of children and youth. Am. J. Prev. Med. 35:547-553.

Berman, M.G., Kross, E., Krpan, K.M., Askren, M.K., Burson, A., Deldin, P.J., Kaplan, S., Sherdell, L., Gotlib, I.H., Jonides, J. 2012. Interacting with nature improves cognition and affect for individuals with depression. J. Affect. Disord. 140:300-305.

Bowler, D., Buyung-Ali, L., Knight, T., Pullin, A. 2010. A systematic review of evidence for the added benefits to health of exposure to natural environments. BMC Public Health 10:456.

Bringslimark, T., Hartig, T., Patil, G.G. 2007. Psychological benefits of indoor plants in workplaces: Putting experimental results into context. HortScience 42:581-587.

Bringslimark, T., Hartig, T., Patil, G.G. 2009. The psychological benefits of indoor plants: A critical review of the experimental literature. J. Environ. Psychol. 29:422-433.

Cariñanos, P., Casares-Porcel, M. 2011. Urban green zones and related pollen allergy: A review. Some guidelines for designing spaces with low allergy impact. Landscape Urban Plan. 101:205-214.

College of Emergency Medicine UK. 2012. Research technical guide. The College of Emergency Medicine http://www.collemergencymed.ac.uk/CEM/Research/technical_guide/hrqol.htm, London.
Dadvand, P., De Nazelle, A., Figueras, F., Basagaña, X., Su, J., Amoly, E., Jerrett, M., Vrijheid, M., Sunyer, J., Nieuwenhuijsen, M.J. 2012a. Green space, health inequality and pregnancy. Environ. Int. 40:110-115.
Dadvand, P., Sunyer, J., Basagana, X., Ballester, F., Lertxundi, A., Fernandez-Somoano, A., Estarlich, M., Garcia-Esteban, R., Mendez, M.A., Nieuwenhuijsen, M.J. 2012b. Surrounding greenness and pregnancy outcomes in four spanish birth cohorts. Environ. Health Perspect. 120:1481-1487.
De Kort, Y.A.W., Meijnders, A.L., Sponselee, A.A.G., IJsselsteijn, W.A. 2006. What's wrong with virtual trees? Restoring from stress in a mediated environment. J. Environ. Psychol. 26:309-320.
De Vries, S., Verheij, R.A., Groenewegen, P.P., Spreeuwenberg, P. 2003. Natural environments - healthy environments? An exploratory analysis of the relationship between greenspace and health. Environ. Plann. A 35:1717-1731.
Donovan, G.H., Michael, Y.L., Butry, D.T., Sullivan, A.D., Chase, J.M. 2011. Urban trees and the risk of poor birth outcomes. Health Place 17:390-393.
Elings, M. 2006. People-plant interaction: The physiological, psychological and sociological effects of plants on people, p.43-55. In: J. Hassink and M. Van Dijk (eds.), Farming for health: Green-care farming across Europe and the United States of America. Springer, New York.
Faber Taylor, A., Kuo, F. 2009. Children with attention deficits concentrate better after walk in the park. J. Attention Disord. 12:402 - 409.
Felsten, G. 2009. Where to take a study break on the college campus: An attention restoration theory perspective. J. Environ. Psychol. 29:160-167.
Fjeld, T., Veiersted, B., Sandvik, L., Riise, G., Levy, F. 1998. The effect of indoor foliage plants on health and discomfort symptoms among office workers. Indoor Built Environ. 7:204-209.
Groenewegen, P.P., Van den Berg, A.E., De Vries, S., Verheij, R.A. 2006. Vitamin G: effects of green space on health, well-being, and social safety. BMC Public Health 6:149.
Groenewegen, P.P., Van den Berg, A.E., Maas, J., Verheij, R.A., De Vries, S. 2012. Is a green residential environment better for health? If so, why? A. Assoc. Am. Geog. 102:996-1003.
Ho, P.M., Peterson, P.N., Masoudi, F.A. 2008. Evaluating the evidence. Circulation 118:1675-1684.
Kahn, P.H., Friedman, B., Gill, B., Hagman, J., Severson, R.L., Freier, N.G., Feldman, E.N., Carrrere, S., Stolyar, A. 2008. A plasma display window? The shifting baseline problem in a technologically mediated natural world. J. Environ. Psychol. 28:192-199.
Kjellgren, A., Buhrkall, H. 2010. A comparison of the restorative effect of a natural environment with that of a simulated natural environment. J. Environ. Psychol. 30:464-472.
Lohr, V.I. 2011. Greening the human environment: The untold benefits. Acta Hortic. 916: 159-169.
Lovasi, G.S., Quinn, J.W., Neckerman, K.M., Perzanowski, M.S., Rundle, A. 2008. Children living in areas with more street trees have lower asthma prevalence. J. Epidemiol. Commun. H. 60:587-592
Maas, J., van Dillen, S.M.E., Verheij, R.A., Groenewegen, P.P. 2009a. Social contacts as a possible mechanism behind the relation between green space and health. Health Place 15:586-595.

Maas, J., Verheij, R., Groenewegen, P., de Vries, S., Spreeuwenberg, P. 2006. Green space, urbanity, and health: how strong is the relation? J. Epidemiol. Commun. H. 60:587 - 592.
Maas, J., Verheij, R.A., de Vries, S., Spreeuwenberg, P., Schellevis, F.G., Groenewegen, P.P. 2009b. Morbidity is related to a green living environment. J. Epidemiol. Commun. H. 63:967-973.
Maas, J., Verheij, R.A., Spreeuwenberg, P., Groenewegen, P.P. 2008. Physical activity as a possible mechanism behind the relationship between green space and health: A multilevel analysis. BMC Public Health 8:206.
Mitchell, R., Astell-Burt, T., Richardson, E.A. 2011. A comparison of green space indicators for epidemiological research. J. Epidemiol. Commun. H. 65:853-858.
Mitchell, R., Popham, F. 2007. Greenspace, urbanity and health: relationships in England. J. Epidemiol. Commun. H. 61:681-683.
Mitchell, R., Popham, F. 2008. Effect of exposure to natural environment on health inequalities: an observational population study. Lancet 372:1655 - 1660.
National Institute for Health and Clinical Excellence 2009. Methods for the development of NICE public health guidance (second edition). National Institute for Health and Clinical Excellence, London.
Paquet, C., Orschulok, T.P., Coffee, N.T., Howard, N.J., Hugo, G., Taylor, A.W., Adams, R.J., Daniel, M. 2013. Are accessibility and characteristics of public open spaces associated with a better cardiometabolic health? Landscape Urban Plan. 118:70-78.
Park, B., Tsunetsugu, Y., Kasetani, T., Kagawa, T., Miyazaki, Y. 2010. The physiological effects of 'Shinrin-yoku'; (taking in the forest atmosphere or forest bathing): evidence from field experiments in 24 forests across Japan. Environ. Health Prev. Med. 15:18-26.
Park, S.H., Mattson, R.H. 2008. Effects of flowering and foliage plants in hospital rooms on patients recovering from abdominal surgery. Horttechnology 18:563-568.
Park, S.H., Mattson, R.H. 2009. Therapeutic influences of plants in hospital rooms on surgical recovery. HortScience 44:102-105.
Raanaas, R.K., Patil, G.G., Hartig, T. 2010. Effects of an indoor foliage plant intervention on patient well-being during a residential rehabilitation program. HortScience 45:387-392.
Raanaas, R.K., Patil, G.G., Hartig, T. 2012. Health benefits of a view of nature through the window: a quasi-experimental study of patients in a residential rehabilitation center. Clin. Rehabil. 26:21-32.
Richardson, E., Pearce, J., Mitchell, R., Day, P., Kingham, S. 2010. The association between green space and cause-specific mortality in urban New Zealand: an ecological analysis of green space utility. BMC Public Health 10:240.
Schwartz, S.H. 1992. Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries, p.1-65. In: P.Z. Mark (ed.), Advances in experimental social psychology. Academic Press.
Stigsdotter, U.K., Ekholm, O., Schipperijn, J., Toftager, M., Kamper-Jorgensen, F., Randrup, T.B. 2010. Health promoting outdoor environments - Associations between green space, and health, health-related quality of life and stress based on a Danish national representative survey. Scand. J. Public Healt. 38:411-417.
Sugiyama, T., Leslie, E., Giles-Corti, B., Owen, N. 2008. Associations of neighbourhood greenness with physical and mental health: do walking, social coherence and local social interaction explain the relationships? J. Epidemiol. Commun. H. 62:e9.
Takano, T., Nakamura, K., Watanabe, M. 2002. Urban residential environments and senior citizens' longevity in megacity areas: the importance of walkable green spaces. J. Epidemiol. Commun. H. 56:913-918.

Thompson Coon, J., Boddy, K., Stein, K., Whear, R., Barton, J., Depledge, M.H. 2011. Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. Environ. Sci. Technol. 45:1761-1772.

Van den Berg, A.E. 2005. Health impacts of healing environments: A review of the benefits of nature, daylight, fresh air and quiet in healthcare settings. Foundation 200 years University Hospital Groningen, Groningen.

Van den Berg, A.E., Hartig, T., Staats, H. 2007. Preference for nature in urbanized societies: Stress, restoration, and the pursuit of sustainability. J. Soc. Issues 63:79-96.

Van den Berg, A.E., Joye, J., De Vries, S. 2012. Health benefits of nature, p.47-56. In: E.M. Steg, A.E. Van den Berg, J. De Groot (eds.), Environmental Psychology: An introduction. Wiley-Blackwell, London.

Van den Berg, M.M.H.E., Maas, J. 2012. Green space and health: A systematic review of the evidence, 11th International People Plant Symposium Baarlo, The Netherlands.

Van Dillen, S.M.E., De Vries, S., Groenewegen, P.P., Spreeuwenberg, P. 2011. Greenspace in urban neighbourhoods and residents' health: adding quality to quantity. J. Epidemiol. Commun. H. 6:e8.

Van Herzele, A., De Vries, S. 2011. Linking green space to health: A comparative study of two urban neighbourhoods in Ghent, Belgium. Popul. Environ.:1-23.

Victora, C.G., Habicht, J.-P., Bryce, J. 2004. Evidence-based public health: Moving beyond randomized trials. Am. J. Public Health 94:400-405.

Wheeler, B.W., White, M., Stahl-Timmins, W., Depledge, M.H. 2012. Does living by the coast improve health and wellbeing? Health Place 18:1198-1201.

White, M.P., Alcock, I., Wheeler, B.W., Depledge, M.H. 2013. Coastal proximity, health and well-being: Results from a longitudinal panel survey. Health Place 23:97-103.