



# Nature Rx: Health Benefits of Spending Time in Nature

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The historical origins of naturopathic medicine and its earliest predecessors and proponents understood the importance of nature exposure in health and healing. The word naturopathic itself comes from the root word ‘nature’, a reminder of our profession’s roots in nature cure.

This early historical emphasis on the health benefits of water, air, sunshine, diet, and herbs amongst historical natural doctors such as Sebastein Kneipp, Vincent Preissnitz, and Arnold Rikli<sup>1</sup> and the guiding principle of the *vis medicatrix naturae* has been reignited by current scientific research into the health benefits of nature. The body of research examining the health benefits of spending time in nature is vast, reflecting the complex, multifaceted interaction we have with our larger ecosystem. It is also challenging, as there are many confounding variables in both our environment and in people which must be taken into account when looking at study methodology and design. Although we are just beginning to tease out the various impacts these connections and interactions have on our health and wellbeing and how we are tied to the rhythms of the planet, we can begin to make sound recommendations and good use of *docere* to help our patients understand and reap the benefits. It is the hope that this article will provide some food for thought and help to inform our practices in ways that will bring the healing power of nature more to the forefront.

## Stress response

Early research into the beneficial effects of nature exposure and green spaces found that natural views provided relaxation, increased positive self-reported emotions, and improved recovery from stress.<sup>2-3</sup> Studies in Japan have explored the relationship between nature exposure and stress in greater detail. Research on the practice of *shinrin-yoku*, walking and/or staying in a forest to promote health, has shown that it can to lower salivary cortisol and subjective stress levels.<sup>4</sup> Studies have also found that the greater the baseline stress levels, the more benefit may be derived from *shinrin-yoku*.<sup>5</sup>

Small controlled studies from Japan have found that forest environments promote lower concentrations of cortisol, pulse rate, blood pressure, and heart rate variability, as well as greater parasympathetic nerve activity, and lower sympathetic nerve activity

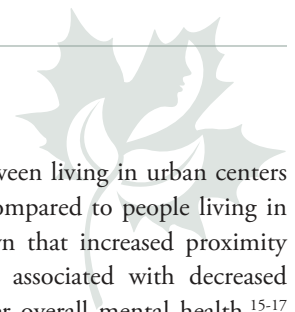
compared to city environments.<sup>6-7</sup> Other studies investigating the effects of short term forest bathing on the stress response have shown similar results. A small study conducted in China, comparing the effects of spending two nights in either a forest or a city environment, found that subjects exposed to the forest environment showed reduced oxidative stress and pro-inflammatory levels compared with the urban group. Serum cortisol levels and the concentration of plasma ET-1, a vasoconstrictor peptide positively correlated to cardiovascular disease, were both significantly lower in subjects exposed to the forest environment.<sup>8</sup>

A larger study performed in Scotland examined the effects of green space and stress on people in socioeconomically deprived urban communities. The study found overall that higher levels of green space, defined as parks, woodlands, scrub and other “natural environments” in proximity to a person’s residence, were correlated with lower cortisol and stress levels. A gender sub-analysis found that women in areas with a lower percentage of green space showed higher levels of stress compared to men. Additionally, they found that women living in areas with a high percentage of green space had healthier diurnal cortisol profiles. These effects on cortisol secretion patterns were not significant amongst the men in the study.<sup>9</sup>

## Immunity

Several studies have investigated the impact of forest bathing on immunity and specific immune system markers. In vitro studies have shown that the phytoncides (antimicrobial allelochemic volatile organic compounds) released by trees may increase natural killer (NK) cell activity. In one study, the essential oils from Japanese cedar (*Cryptomeria japonica*) and cypress (*Chamaecyparis obtuse*) significantly increased the cytolytic activity of NK cells, measured through the induction of intracellular release of granzyme A, and perforin.<sup>10</sup> NK cell activity increased in a dose-dependent manner, even in cells exposed to organophosphorus pesticide.

Human studies in forest settings have confirmed the in vitro findings. A small Japanese study including healthy men, evaluated immune markers after 3 days and 2 nights in a forest. Participants walked 2.5 km on day 1, followed by two 2.5 km walks on day 2. NK cell counts and activity significantly increased from the baseline measurement, as did the levels of perforin, granzyme A and granzyme B.<sup>11</sup> A similar study in healthy female nurses also showed significant increases in NK cell counts and activity, with the effects lasting for at least 7 days after the trip had ended.<sup>12</sup>



A follow-up controlled study of healthy male participants, compared immunological markers during and after 3 days/2 nights stay in either a primarily coniferous forest or urban setting. NK cell counts and activity, as well as the percentages of perforin- granulysin-, granzymes A/B- expressing lymphocytes, significantly increased after the forest visit, whereas no such change was noted after the city visit. Additionally, the rise in NK cell activity persisted for at least 7 days and up to 30 days after the forest visit.<sup>13</sup>

Other immune markers have been less well studied. A study of healthy male university students in China measured cytokine and lymphocytes after 2 days of gentle walking (1.5 hr twice daily), randomized to either a forest or urban setting. While inflammatory cytokines were not significantly different between the two groups at baseline, both IL-6 and TNF- $\alpha$  were significantly decreased in the forest group compared to the urban group after 2 days. Decreases in C-reactive protein and T-suppressor cells, as well as increases in B-, T-helper lymphocytes and NK cells were found in the forest group but the differences were not significant.<sup>8</sup>

## KEY FACTS

- Nature cure is part of the historical basis for naturopathic medicine
- Nature exposure may reduce both the physiological and psychological experience of stress
- Forest bathing among conifers may improve immune system functioning
- Proximity to green space is associated with increases in self-esteem, mood, and vitality
- Spending time in nature may also decrease rumination
- Inverse relationships have been identified between proximity to green space and obesity or ADHD in children
- Tree canopy cover is associated with better birth outcomes
- Access to green space is associated with greater life expectancy and lower risk of cardiovascular disease
- Health benefits may be greater in women and those with lower socioeconomic status
- Benefits may not be consistent across different climates, cultures, or in developing countries

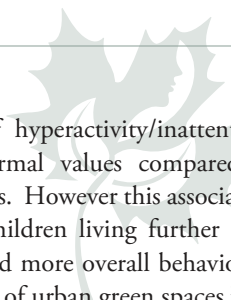
## Mood

Studies have shown an association between living in urban centers and increased rates of mental illness compared to people living in rural areas.<sup>14</sup> Other studies have shown that increased proximity to and use of urban green spaces is associated with decreased anxiety and mood disorders, and better overall mental health.<sup>15-17</sup> One study found that this relationship was statistically significant amongst women but not for men.<sup>18</sup> Although it is nearly impossible to identify all the factors that contribute to this association, some researchers have speculated that urban tree cover and access to natural environments are an important cofactor. Evidence also shows that intentional exposure to nature is associated with better mental health outcomes. Some studies have shown improvements in mood with simply a view of green space in a picture<sup>19</sup> or from a window.<sup>2</sup>

Exercising in nature, also known as green exercise, may have additional benefits on mental health. A meta-analysis of 10 non-controlled studies, including 1252 participants, found that green exercise significantly improved both mood and self-esteem. Measured using the Rosenberg Self-Esteem Scale and the Profile of Mood States (POMS), green exercise improved self-esteem by approximately 45% and mood by over 50%.<sup>20</sup>

Forest bathing studies from Japan and China have supported these findings. In small, controlled studies, gentle walking in a forest setting has been found to significantly improve mood compared to walking in an urban environment. POMS scores on tension/anxiety, fatigue and confusion were significantly decreased, while sense of vigor was increased after the forest visit compared to baseline measurements. In contrast, walking in an urban area increased fatigue and decreased vigor compared to baseline.<sup>21</sup> Another study found that forest exposure decreased tension/anxiety, depression/dejection, and anger/hostility compared to the urban exposure control group.<sup>8</sup>

More recently, researchers have begun to explore the mechanisms behind the improvements in mood found in earlier studies. In a study conducted at Stanford University, researchers compared subjective levels of rumination and subgenual prefrontal cortex (sgPFC) brain activity (an area shown to be more active with rumination and negative self-talk) in 38 healthy participants, randomized to a 90 minute walk in either a natural or urban environment. Compared to baseline levels, the participants on the nature walk showed a significant decrease in self-reported level of rumination after their walks, while those on the urban walk did not. Corresponding to subjective findings, blood perfusion in the sgPFC area significantly decreased after the nature walk but not after the urban walk. sgPFC activity was also significantly different between the two groups.<sup>22</sup> More research is needed to elucidate whether or not improvements in mood found in these studies would also be seen with people who have been diagnosed with specific mental health conditions.



## Pediatric health considerations

### ***Green Space and Obesity:***

A longitudinal study conducted in Australia following children from age 6 to 13 found an inverse relationship between body mass index (BMI) and access to greenspace. The beneficial effect emerged more strongly as the children grew older.<sup>23</sup> A higher density of trees (the 75th versus the 25th percentile) has been associated with a 12% lower prevalence of obesity in New York preschool children from low income families.<sup>24</sup>

This effect may be related to findings of another study which examined physical activity in children and greenspaces, including treed areas and meadows. This study found that meadows were not associated with higher physical activity outcomes. However, for each additional 5% increase in the proportion of neighborhood land covered by treed areas there was a corresponding 5% increase in the relative odds of increasing free-time physical activity outside of school hours.<sup>25</sup>

A cross-sectional study examined the risks and benefits of green spaces for children. It looked at sedentary behaviour, obesity, asthma and allergy. The authors found that an interquartile range increase in residential surrounding greenness was associated with 11-19% lower relative prevalence of overweight/obesity and excessive screen time, but was not associated with current asthma and allergic rhinoconjunctivitis. Residential proximity to forests was associated with 39% and 25% lower relative prevalence of excessive screen time and overweight/obesity, respectively, but was not associated with current asthma. In contrast, living close to parks was associated with a 60% higher relative prevalence of current asthma, but had only weak negative associations with obesity/overweight or excessive screen time.<sup>26</sup>

### ***Green Space and ADHD:***

A study conducted in Barcelona looked at the impact of contact with green spaces and blue spaces (beaches) on indicators of behavioural development and symptoms of attention deficit/ hyperactivity disorder (ADHD). They discovered statistically significant inverse relationship between green space, playing time and Strengths and Difficulties Questionnaires (SDQ) total difficulties, emotional symptoms, and peer relationship problems. The same relationship was found between residential surrounding greenness and SDQ total difficulties and hyperactivity/inattention and ADHD/DSM-IV total and inattention scores; and between annual beach attendance and SDQ total difficulties, peer relationship problems, and prosocial behavior. There did not seem to be a relationship between beach attendance and ADHD symptom scores. The most important factor was that children interacted with the spaces. Effects of residential proximity to green spaces were inconclusive.<sup>27</sup>

In a study conducted in Munich, the authors found that the distance between a child's residence and the nearest urban green space was

positively associated with the odds of hyperactivity/inattention, especially among children with abnormal values compared to children with borderline or normal values. However this association was only significant among males. Children living further than 500m away from urban green spaces had more overall behavioural problems than those living within 500m of urban green spaces.<sup>28</sup>

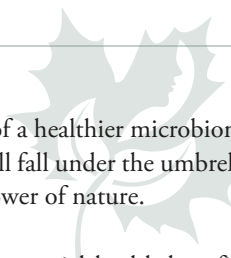
### **Pregnancy Outcomes:**

Studies have been conducted linking stress levels to pregnancy outcomes<sup>29</sup> and this has been examined in the context of neighborhood level economic deprivation<sup>30-31</sup> and social capital<sup>32</sup>. Recently there have been a number of studies examining the link between proximity to green space and pregnancy outcomes.

Some of these studies have examined the connection between proximity to green space, tree cover, and birthweight outcomes. Living within 50m of a canopy cover and access to a private open space reduced the risk of babies being born small for gestational age. However this effect could be a manifestation of higher socioeconomic status as women with greater access to urban trees were more likely to be non-hispanic white, younger, have fewer previous births and live in newer, more expensive houses closer to private open space.<sup>33</sup>

A study conducted in Vancouver found an interquartile increase in greenness, measured using satellite images and the Normalized Difference Vegetation Index (NDVI), was associated with higher term birth weight and decreases in the incidence of small for gestational age, very preterm (< 30 weeks), and moderately preterm (30-36 weeks) births. These associations remained after controlling for variables such as air pollution, noise exposures, neighborhood walkability and park proximity.<sup>34</sup> Another study found that an interquartile increase in green space resulted in statistically significant increases in birth weight and a decrease in low birth weight. Very low birth weight also decreased but did not reach statistical significance. This study found no association between pre-term delivery and very pre-term delivery and green space. The effects were more pronounced for mothers of lower socio-economic status.<sup>35</sup>

This association however, appears to vary between ethnic and socioeconomic groups. A study conducted in the UK examining ethnicity and individual and neighborhood socioeconomic status and pregnancy outcomes found an overall positive association between birthweight and surrounding residential greenness. However this effect was more pronounced with white participants. The correlation was not shown for participants of Pakistani descent. Furthermore, it was found that larger areas of greenness (500m to 1000m) had a more pronounced effect on birthweight in participants with lower education and those living in more socioeconomically deprived neighborhoods versus smaller areas of greenness (50m - 200m) in the same populations. The authors did not speculate as to the reasons for the discrepancies and stated that more detailed studies were needed to better understand this effect.<sup>36</sup> An earlier study conducted in Spain found no association between proximity to green space and



pregnancy outcomes until they adjusted for maternal education and found that proximity to green space was associated with higher birth weights in women with the lowest educational level.<sup>37</sup> Overall the greatest benefit of proximity to green space seems to be derived from women of low socioeconomic status.

### Life Expectancy and Mortality:

Access to parks and forests may have a positive impact on life expectancy. There is evidence that people living in counties with higher natural resource amenities have higher life expectancies at birth than counties with lower amenities after controlling for socio-demographic and economic factors, medical facilities and risk factors.<sup>38</sup> Researchers investigating the impact of walkable green streets have also found significant increases in the 5 year survival of senior citizens living in Tokyo.<sup>39</sup>

Other studies have found that having 10 more trees per city block is associated with improved health perception comparable to an increase in annual personal income of \$10,000 and moving to a neighborhood with \$10,000 higher median income or being 7 years younger; having an average of 11 more trees per block was associated with decreases in cardiometabolic conditions comparable to an increase in annual personal income of \$20,000 and moving to a neighborhood with \$20,000 higher median income or being 1.4 years younger.<sup>40</sup>

### Discussion

The health benefits of spending time in nature have the potential to be extensive, and have positive impacts on the whole person, in mind, body and spirit. Studies not reviewed here have found associations between nature exposure and cognition, blood pressure and other cardiovascular variables, blood sugar and insulin resistance in diabetics, subjective pain ratings, circadian rhythms, and many more health parameters.

The standardized extract or active constituent of time spent in nature is elusive. It is difficult to parse out the factors involved in the health benefits derived from the interplay between person and environment. While Japanese researchers have primarily attributed these salutogenic effects to the volatile oils released by trees (especially conifers), there are likely many other contributing factors. The pollution removal that trees perform has large impacts on human health, in particular air quality within urban centres.<sup>41</sup> Research in environmental psychology has suggested that green spaces have positive health effects through stress reduction, feelings of safety, and increased social integration and healthy behaviours including exercise.<sup>42</sup> Sensory stimulation, visual focus and field of view are theorized to be salient factors, in particular in the research regarding children and ADHD. Increased exposure to sunlight and vitamin D as people spend more time outside are also likely involved. Nature exposure may also impact health through the development of, or changes to, our microbiomes. Drawing from the hygiene hypothesis, Alan Logan has theorized that grey space in urban centres promotes dysbiosis, while increased exposure to nature may

inversely be related to the development of a healthier microbiome.<sup>43</sup> Synthesized together, these factors may all fall under the umbrella of the *vis medicatrix naturae*, the healing power of nature.

Much of the research available on the potential health benefits of spending time in nature has been in small-scale poorly designed trials. Field studies are very difficult to reproduce, due to the variability of weather, temperature, humidity and other factors that are not controllable. Additionally, study participants from the majority of the Japanese studies were healthy men in their early 20s attending university. The homogenous and limited demographic group makes it difficult to extrapolate findings to other people, most notably women. Many larger, population-based studies have been primarily conducted in temperate regions of Europe and North America. Studies in tropical climates have not yielded similarly positive results.<sup>44</sup> The majority of studies have attempted to account for socioeconomic status, and it seems that the benefits may exist independent of this particular factor. Populations of low socioeconomic status may, however, derive a greater magnitude of benefit from access to green spaces. The mechanisms for this effect, have not been fully explored as the studies are correlational and would require further large-scale research to flesh out the connections. While the research overall is very promising, more studies are needed to more definitively inform clinical recommendations to patients.

Nonetheless, the potential harm of spending time in nature is quite limited, especially with education around physical exercise, safety and environmental considerations. In other words, there is very little downside to nature exposure and broad potential benefits. Proximity to and use of green space may help provide a buffer against the negative effects of acute and chronic stress<sup>45</sup>, reduce cardiovascular risk<sup>16</sup> and obesity, and may have beneficial effects on birth weight and aid in decreasing symptoms of ADHD.

In spite of the limited scientific evidence available, clinicians should encourage their patients to get outside into nature where possible, for stress management, mental health promotion, overall health promotion, and to a connection to the *vis medicatrix naturae*. Just as Aldoph Just once advocated for a “Return to Nature!” with his book title of the same name, today’s naturopathic physicians should also advocate for greater access and use of green spaces for overall health promotion. 🌿



## About the Authors

**Dr. Cyndi Gilbert, ND** is a licensed naturopathic doctor and clinic supervisor at Queen West Community Health Centre, a satellite clinic of the Canadian College of Naturopathic Medicine. She has a special interest in philosophy, particularly as it relates to the sociocultural aspects of health and the interpretation and praxis of naturopathic principles. She maintains a general family practice in Toronto, Ontario and is a regular contributor to various journals and magazines. Her new book, *The Essential Guide to Women's Herbal Medicine*, was published earlier this summer. Learn more at [www.cyndigilbert.ca](http://www.cyndigilbert.ca).

**Dr. Katie Smith, ND** is a licensed naturopathic doctor who has been practicing since 2013. She is currently on maternity leave after completing a clinical residency at the Boucher Institute of Naturopathic Medicine. She completed her naturopathic medical diploma from the Canadian College of Naturopathic Medicine where she was selected to receive the Naturopathic Honour Award for her graduating class. She also holds a bachelor's degree in honours kinesiology with a minor in psychology from McMaster University.

Dr. Smith currently resides in Toa Baja, Puerto Rico with her son and partner, where she hopes to begin practice once she completes her maternity leave. She has a special interest in community health, chronic pain and pediatrics. She also has an interest in global health and has traveled to Haiti to volunteer with Naturopaths Without Borders and Mama Baby Haiti, and has been a speaker for AMREF (African Medical and Research Foundation).

## References

- Kirchfeld F, Boyle W. *Nature Doctors: Pioneers in Naturopathic Medicine*. Portland, OR: NCNM Press; 2005.
- Ulrich RS. View through a window may influence recovery from surgery. *Science*. 1984 Apr 27; 224(4647): 420-1.
- Ulrich RS, Simons RF, Losito BD, Fiorito E, Miles MA, Zelson M. Stress recovery during exposure to natural and urban environments. *J Environ Psychol*. 1991; 11(3): 201-230.
- Park BJ, Tsunetsugu Y, Kasetani T, et al. Physiological effects of Shinrin-yoku (taking in the atmosphere of the forest) – using salivary cortisol and cerebral activity as indicators. *J Physiol Anthropol*. 2007 Mar; 26(2): 123-8.
- Morita E, Fukuda S, Nagano J, et al. Psychological effects of forest environments on healthy adults: Shinrin-yoku (forest-air bathing, walking) as a possible method of stress reduction. *Public Health*. 2007 Jan; 121(1): 54-63.
- Park BJ, Tsunetsugu Y, Kasetani T, Kagawa T, Miyazaki Y. 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*. 2010 Jan; 15(1): 18-26.
- Lee J, Park BJ, Tsunetsugu Y, Ohira T, Kagawa T, Miyazaki Y. Effect of forest bathing on physiological and psychological responses in young Japanese male subjects. *Public Health*. 2011 Feb; 125(2): 93-100.
- Mao GX, Lan XG, Cao YB, et al. Effects of short-term forest bathing on human health in a broad-leaved evergreen forest in Zhejiang Province, China. *Biomed Environ Sci*. 2012 Jun; 25(3): 317-24.
- Roe JJ, Thompson CW, Aspinall PA, et al. Green space and stress: evidence from cortisol measures in deprived urban communities. *Int J Environ Res Public Health*. 2013 Sep 2; 10(9): 4086-103.
- Li Q, Nakadai A, Matsushima H, et al. Phytoncides (wood essential oils) induce human natural killer cell activity. *Immunopharmacol Immunotoxicol*. 2006; 28(2): 319-33.
- Li Q, Morimoto K, Nakadai A, et al. Forest bathing enhances natural killer cell activity and expression of anti-cancer proteins. *Int J Immunopathol Pharmacol*. 2007 Apr-Jun; 20(2 Suppl 2): 3-8.
- Li Q, Morimoto K, Kobayashi M, et al. A forest bathing trip increases natural killer activity and expression of anti-cancer proteins in female subjects. *J Biol Regul Homeost Agents*. 2008 Jan-Mar; 22(1): 45-55.
- Li Q, Morimoto K, Kobayashi M, et al. Visiting a forest, but not a city, increases human natural killer activity and expression of anti-cancer proteins. *Int J Immunopathol Pharmacol*. 2008 Jan-Mar; 21(1): 117-27.
- Peen J, Schoevers RA, Beekman AT, Dekker J. The current status of urban-rural differences in psychiatric disorders. *Acta Psychiatr Scand*. 2010; 121(2): 84-93.
- Nutsford D, Pearson AL, Kingham S. An ecological study investigating the association between access to urban green space and mental health. *Public Health*. 2013 Nov; 127(11): 1005-11.
- Richardson EA, Pearce J, Mitchell R, Kingham S. Role of physical activity in the relationship between urban green space and health. *Public Health*. 2013 Apr; 127(4): 318-24.
- Gascon M, Triguero-Mas M, Martinez D, et al. Mental health benefits of long-term exposure to residential green and blue spaces: a systematic review. *Int J Environ Res Public Health*. 2015 Apr 22; 12(4): 4354-79.
- Reklaitiene R, Grauleviciene R, Dedele A, et al. The relationship of green space, depressive symptoms and perceived general health in urban population. *Scand J Public Health*. 2014 Nov; 42(7): 669-76.
- Pretty J, Peacock J, Sellens M, Griffin M. The mental and physical health outcomes of green exercise. *Int J Environ Health Res*. 2005 Oct; 15(5): 319-37.
- Barton J, Pretty J. What is the best dose of nature and green exercise for improving mental health? A multi-study analysis. *Environmental Science and Technology*. 2010; 44(10): 3947-55.
- Takayama N, Korpela K, Lee J, et al. Emotional, restorative and vitalizing effects of forest and urban environments at four sites in Japan. *Int J Environ Res Public Health*. 2014 Jul; 11(7): 7207-7230.
- Bratman GN, Hamilton JB, Hahn KS, Daily GC, Gross JJ. Nature experience reduces rumination and subgenual prefrontal cortex activation. *Proc Natl Acad Sci U S A*. 2015 Jul 14; 112(28): 8567-72.
- Sanders T, Feng X, Fahey PP, Lonsdale C, Astell-Burt T. Greener neighbourhoods, slimmer children? Evidence from 4423 participants aged 6 to 13 years in the Longitudinal Study of Australian Children. *Int J Obes (Lond)*. 2015 Aug; 39(8): 1224-9.
- Lovasi GS, Schwatz-Soicher O, Quinn JW, et al. Neighbourhood safety and green space as predictors of obesity among preschool children from low-income families in New York City. *Prev Med*. 2013 Sep; 57(3): 189-93.
- Janssen I, Rosu A. Undeveloped green space and free-time physical activity in 11 to 13-year-old children. *Int J Behav Nutr Phys Act*. 2015 Feb 21; 12: 26.
- Dadvand P, Villanueva CM, Font-Ribera L, et al. Risks and benefits of green spaces for children: a cross-sectional study of associations with sedentary behaviour, obesity, asthma, and allergy. *Environ Health Perspect*. 2014 Dec; 122(12): 1329-35.
- Amoly E, Dadvand P, Fors J, et al. Green and blue spaces and behavioural development in Barcelona schoolchildren: the BREATHE project. *Environ Health Perspect*. 2014 Dec; 122(12): 1351-8.
- Markevych I, Tiesler CM, Fuertes E, et al. Access to urban green spaces and behavioural problems in children: Results from the GINIplus and LISAPLUS studies. *Environ Int*. 2014 Oct; 71: 29-35.
- Miranda ML, Maxson P, Edwards S. Environmental contributions to disparities in pregnancy outcomes. *Epidemiol Rev*. 2009; 31: 67-83.
- Messer LC, Vinikoor LC, Laraia BA, et al. Socioeconomic domains and associations with preterm birth. *Soc Sci Med*. 2008 Oct; 67(8): 1247-57.
- Buka SL, Brennan RT, Rich-Edwards JW, Raudenbush SW, Earls F. Neighbourhood support and the birth weight of infants. *Am J Epidemiol*. 2003 Jan 1; 157(1): 1-8.
- O'Campo P, Burke JG, Culhane J, et al. Neighbourhood deprivation and preterm birth among non-Hispanic Black and White women in eight geographic areas in the United States. *Am J Epidemiol*. 2008 Jan 15; 167(2): 155-63.
- Donovan GH, Michael YL, Butry DT, Sullivan AD, Chase JM. Urban trees and the risk of poor birth outcomes. *Health Place*. 2011 Jan; 17(1): 390-3.
- Hystad P, Davies HW, Frank L, et al. Residential greenness and birth outcomes: evaluating the spatially correlated built-environment factors. *Environ Health Perspect*. 2014; 122(10): 1095-102.
- Agay-Shay K, Peled A, Crespo AV, et al. Green spaces and adverse pregnancy outcomes. *Occup Environ Med*. 2014 Aug; 71(8): 562-9.
- Dadvand P, Wright J, Martinez D, et al. Inequality, green spaces, and pregnant women: roles of ethnicity and individual and neighbourhood socioeconomic status. *Environ Int*. 2014 Oct; 71: 101-8.
- Dadvand P, de Nazelle A, Figueras F, et al. Green space, health inequality and pregnancy. *Environ Int*. 2012 Apr; 40: 110-5.
- Poudyal NC, Hodges DG, Bowker JM, Cordell HK. Evaluating natural resource amenities in a human life expectancy production function. *For Policy Econ*. 2009; 11(4): 253-9.
- Takano T, Nakamura K, Watanabe M. Urban residential environments and senior citizens' longevity in megacities: the importance of walkable green spaces. *J Epidemiol Community Health*. 2002 Dec; 56(12): 913-8.
- Kardan O, Gozdyra P, Misis B. Neighbourhood green space and health in a large urban center. *Sci Rep*. 2015 Jul 9; 5: 11610.
- Nowak DJ, Hirabayashi S, Bodine A, Greenfield E. Tree and forest effects on air quality and human health in the United States. *Environ Pollut*. 2014 Oct; 193: 119-29.
- Groenewegen PP, van den Berg AE, de Vries S, Verheij RA. Vitamin G: effects of green space on health, well-being, and social safety. *BMC Public Health*. 2006; 6: 149. doi:10.1186/1471-2458-6-149.
- Logan AC. Dysbiotic drift: mental health, environmental grey space, and microbiota. *J Physiol Anthropol*. 2015; 34(1): 23. doi: 10.1186/s40101-015-0061-7.
- Saw le E, Lim FK, Carrasco LR. The relationship between natural park usage and happiness does not hold in a tropical city-state. *PLoS ONE*. 2015; 10(7): e0133781. doi: 10.1371/journal.pone.0133781.
- van den Berg AE, Maas J, Verheij RA, Groenewegen PP. Green space as a buffer between stressful events and health. *Soc Sci Med*. 2010 Apr; 70(8): 1203-10.