Swiss Re Institute

October 2021

Biodiversity and the benefits for human health

Time spent in nature is proven to be of enormous benefit to our physical and mental health.

Spending more time in nature settings and constructing and integrating green spaces in urban environments is likely to prove fruitful in reducing medical cost for societies and insurers alike – prevention is a public health issue. Construction and operation of green spaces can be insured against a variety of risks.

Introduction

Biodiversity loss is the twin risk of climate change.

Together with climate change – and indivisibly interlinked – biodiversity loss has emerged as one of the twin environmental challenges of our century. Scientists and international stakeholders have repeatedly demonstrated that biodiversity underpins ecosystem services which provide essential benefits to societies and economies and ultimately to the foundations of our lives: food provision, clean water, shelter, and health. These foundations continue to be endangered through biodiversity loss and ecosystem degradation.[1,2] Human use of land and sea, exploitation of natural resources, pollution, invasive species, and climate change itself are the key drivers for biodiversity loss. This is a situation we cannot afford. Working on reducing the drivers that lead to biodiversity loss, creating greener areas and investing into regeneration and restoration can turn the trend around and help unleash the benefits that go along with biodiversity.

Biodiversity benefits are many and varied; here we focus on health.

Science has made huge progress in explaining, for example, the role of biodiversity in building fertile soils or supporting pollination. More recently, research has demonstrated how biodiversity benefits human health, building a strong case for conservation even beyond the current UN's decade of ecosystem restoration. This publication elaborates on those risks to health that can be positively influenced by nature and our live-in environment, with a focus on five major health issues: mental health, cardiovascular disease and exposure to air pollution, heat, and noise.[3]

1 IPBES 2019. *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).* E. S. Brondizio, J. Settele, S. Díaz, and H. T. Ngo (editors). IPBES secretariat, Bonn, Germany. https://ipbes.net/global-assessment.

2 IPCC 2019. *Summary for Policymakers. In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.* P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.- O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.).

3 For detailed examples on the importance of biodiversity for human health, see M.R. Marselle, J. Stadler, H. Korn, K.N. Irvine, A. Bonn; editors 2019. *Biodiversity and health on the face of climate change*. Springer, Cham. Also see D. Martinoli, L. Crump, J. Zinsstag. 2019. Biodiversity, a guarantee of health? Swiss Academy of Sciences (SCNAT) factsheets Vol. 14., No. 3 2019, Forum Biodiversity Switzerland, Bern. Literature is evolving quickly, and the references provided here provide first, but relevant insights into the topic.

Scientific insights into the health benefits of nature

The role of nature for mental health

The association of mental health and nature has been a long one. The father of medicine, Hippocrates, stated "nature itself is the best physician." Scientific evidence has been more nuanced and heterogeneous in its findings, but the evidence remains compelling.[4]

The direct costs and productivity losses of poor mental health are huge.

The global economic burden of mental illness is enormous, estimated at USD 2.5 trillion in 2010 and projected to reach USD 6.0 trillion by 2030.[5] This topic has gained traction in recent years, not least among employers. The most common cause of workplace absence is mental health, followed by cancer (Goetzel et al. 2002).[6] Most mental health costs are non-medical, including loss of productivity, reduced returns, or in extreme cases loss of staff. For example, the annual cost of depression alone to the Australian or Japanese workforces has been estimated above USD 10 billion in each of the countries.[7,8] Several studies assign annual corporate mental health costs per employee from USD 10 to USD 550.[9]

A key matter for us all, mental health is equally important for health insurers. Mental health protection goes beyond insuring losses associated with treatment.

Numerous studies positively associate time in nature with improved mental health.

Time spent in nature can reduce mental health risks and increase psychological well-being. Nature's support for mental health can be regarded as an ecosystem service (Bratman et al. 2019).[10] Meta-analyses point to a moderate influence of nature on mental health, although results are often heterogenous due to varying definitions of nature and mental health, as well as small sample sizes in medical research.[11] The 18-country survey conducted by White et al. (2021) revealed the complexity of the relationship of nature and health. The study collected data from residential exposure to green spaces (satellite imagery of a 1 km buffer around the home) and recreational visits (self-reported visit frequency in the last four weeks). They also explored whether individuals had both inland-blue and coastal-blue space within 1 km buffers of their home; and how often they had visited each type of blue space in the 4 weeks preceding the survey.

4 C. Twohig-Bennett, A. Jones 2018. *The health benefits of the great outdoors: A systematic review and meta-analysis of greenspace exposure and health outcomes.* Environmental Research 166 (2018) 628-637.

5 C. Sabariego, M. Miret, M. Coenen 2017. *Global mental health: Costs, poverty, violence, and socioeconomic determinants of health.* In D. Razzouk (Ed.), Mental health economics: The costs and benefits of psychiatric care (pp. 365–379). Springer International Publishing. https://doi.org/10.1007/978-3-319-55266-8_24.

6 R.Z. Goetzel, R.J. Ozminkowski, L.I. Sederer, T.L. Mark 2002. *The Business Case for Quality Mental Health Services: Why employers should care about the mental health and well-being of their employees.* American College of Occupational and Environmental Medicine. JOEM Vol. 44, no. 4, April 2002, 320-330.

7 A.D. LaMontagne, K. Sanderson, F. Cocker 2010. *Estimating the economic benefits of eliminating job strain as a risk factor for depression.* Victorian Heath Promotion Foundation (VicHealth), Carlton

8 J. Chen, V. Wang 2021. *Mental health in Japan. An opportunity for insurance to help close the protection gap.* Swiss Re Institute 2021. According to OECD 2018 suicide rates, lifetime mental illness incidence in Japan is around 22% and the suicide rate stood at 14.7 per 100 000 people in 2017. Further, Chen and Wang quote the study by Y. Okumura, T. Higuchi Cost of Depression Among Adults in Japan. Prim Care Companion CND Disord 2011.

9 W.P. McTernan, M.F. Dollard, A.D. LaMontagne 2013. *Depression in the workplace: An economic cost analysis of depression-related productivity loss attributable to job strain and bullying.* Work & Stress. An International Journal of Work, Health & Organisations. Vol 27, 2013 Issue 4, Pages 321-338. PwC and Beyond Blue 2014, Creating a mentally healthy workplace: Return on investment analysis.

10 G.N. Bratman. et al. 2019. *Nature and mental health: An ecosystem service perspective.* Sciences Advances 5 (7), eaax0903, DOI: 10.1126/sciadv.aax0903

11 M. Gascon et al. 2015 examined 28, McMahan and Estes 2014 32 studies and Gritzka et al. 2020 9 studies (focused only on nature-based interventions at the workplace) in their meta-analyses. See M. Gascon, M. Triguero-Mas, D. Martinez, P. Dadvand, J. Forns, A. Plasencia, M.J. Nieuwenhuijsen 2015. *Mental Health Benefits of Long-Term Exposure to Residential Green and Blue Spaces: A Systematic Review.* International Journal of Environmental Research and Public Health 2015 Apr., 12 (4): 4354-4379. E.A. McMahan, D. Estes. 2014. *The effect of contact with natural environments on positive and negative affect: A meta-analysis.* The Journal of Positive Psychology, 10:6, 507-519, DOI: 10.1080/17439760.2014.994224. S. Gritzka, T.E. MacInyre, D. Dörfel, J.L. Baker-Blanc, G. Calogiuir. 2020. *The Effects of Workplace Nature-Based Interventions on the Mental Health and Well-Being of Employees: A Systematic Review.* Frontiers in Psychiatry 2020 Apr 28; 11:323 doi: 10.3389/fpsyt.2020.00323.

Associations between positive well-being, mental distress, depression/anxiety medication were used as 'mental' indicators and compared with residential or recreational exposures to a variety of natural settings such as green, inland-blue, or coastal-blue. Additionally, the influence of individual connectivity to nature and seasonal variables was also considered. The authors concluded that both general daily connections with nature as well as recreational visits to green, inland-blue, or coastal-blue areas were positively associated with mental well-being and negatively associated with mental distress. People living in green or coastal areas reported higher positive well-being; however, the association disappeared when recreational visits were controlled.[12]

Access to green spaces for urban dwellers is especially beneficial.

Life and health insurers look holistically at the many different factors which influence an individual's health. Access to, and time spent in nature are contributing, but not determining factors, to an individual's mental health outcome. Especially from a preventive perspective, exposure to nature as a contributor to mental health cannot be ignored. The definition of how 'nature' and 'mental well-being' are classified is of importance. It matters whether the goal of spending time in nature is a matter of chance – or whether it is to achieve a specific health ambition. In a collection of field studies in forests throughout Japan, Park et al. (2010) demonstrate the mental benefits of green spaces through the activity of "Shinrin-yoku" (forest 'bathing' or taking in the forest atmosphere). Those who walked in the Seiwa Prefecture Forest Park showed significantly lower haemoglobin concentrations than a control group walking in a city. Similar results were shown in cortisol levels by those walking in the Yamagata Prefecture Forest than an urban control group.[13,14] Haemoglobin and cortisol are both biomarkers which can be used as proxies for stress levels. If left unchecked, stress is a major contributor to conditions such as burn-out. Thus far, biomarkers have not been extensively used in mental health research due to their lack of specificity, consistency and reliability, as well as limited access.[15]

Access to nature also helps during the COVID-19 pandemic.

The COVID-19 pandemic has highlighted the importance of nature for mental health. As 2020 sprung an unexpected, global, physical health state of emergency, a silent mental health crisis began to brew, further worsened by the restriction of movement, quarantines and lockdowns. Intuitively, the mental health of those fortunate to live within easy walking distance of green environments was better than those forced to isolate in dense urban areas with little access to green space. Soga et al. (2020) conducted research on 3 000 residents in Tokyo, correlating five mental health outcomes (depression, life satisfaction, subjective happiness, self-esteem, and loneliness) with two nature-centric measures (frequency of green space use and visibility of green views through windows from one's home).[16] They concluded that greenspace use, or even just the existence of green window views, was associated with increased levels of self-esteem, life satisfaction, subjective happiness – and decreased levels of depression, anxiety, and loneliness.[17]

Gardening supports social cohesion.

Communal activities in green spaces – such as sport or gardening – provide an important source of social cohesion and support for mental health. Lampert et al in 2021 report that community gardens provide both mental and physical health gains.[18]

[12] M.P. White, L.R. Elliott, J. Grellier et al. *Associations between green/blue spaces and mental health across 18 countries.* Sci Rep 11, 8903 (2021). https://doi.org/10.1038/s41598-021-87675-0

[13] B.J. Park, Y.Tsunetsugu, T. Kasetani, T. Kagawa, Y. Miyazaki 2010. *The physiological effects of Shinrin-yoku (taking in the forest atmosphere or forest bathing): evidence from field experiments in 24 forests across Japan.* Environmental Health and Preventive Medicine 2010 Jan; 15(1): 18.26. doi 10.1007/s12199-009-0086-9

[14] Djernis et al. 2019 meta-analysis confirms positive effects of nature on psychological, as well as physical and social conditions. D. Djernis, I. Lerstrup, D. Poulsen, U. Stigsdotter, J. Dahlgaard, M. O'Toole. *A Systematic Review and Meta-Analysis of Nature-Based Mindfulness: Effects of Moving Mindfulness Training into an Outdoor Natural Setting.* Int J Environ Res Public Health. 2019 Sep 2;16(17):3202. doi: 10.3390/ijerph16173202. PMID: 31480748; PMCID: PMC6747393

[15] Hidalgo-Mazzei and Young 2018 draw on monitoring from mobile technology to measure not only blood chemicals but other biomarkers such as pulse, allowing a more holistic and integrative approach to mental health research. D. Hidalgo-Mazzei, A.H. Young 2018. *Psychiatry foretold.* Australian & New Zealand Journal of Psychiatry. Vol. 53 Issue 4, p. 365-366. https://doi.org/10.1177/0004867418816821

[16] M. Soga et al. 2020. *A room with a green view: the importance of nearby nature for mental health during the COVID-19 pandemic.* Ecological Applications 0 (0), 2020, e02248. 10.1002/eap.2248

[17] Ibid.

[18] T. Lampert et al. *Evidence on the contribution of community gardens to promote physical and mental health and well-being of non-institutionalized individuals: A systematic review.* PLoS One. 2021;16(8):e0255621. Published 2021 Aug 6. doi:10.1371/journal.pone.0255621

With a significant protection gap, mental health products could be a new insurance risk pool.

Insurance perspective far from being a subsidiary

Good mental health is far from a subsidiary and an additional bonus to physical health; the costs associated with poor mental health are high and carried by individuals and societies. For the health insurance industry, the importance of mental health is growing. In many countries, private mental health insurance is in its infancy; delayed by early signs of mental health problems being lost in cultural tradition; the stigma of seeking help; constraints on underwriting capacity; and a lack of acknowledgement of consumers' interests. The significant global mental health protection gap represents a large potential risk pool and consequently an opportunity for the insurance sector. Treatment coverage may be designed suboptimal. This is particularly the case if health provision is structured around high reimbursements for hospitalisation or direct medical costs – which tend to result later in longer hospital stays and intensive medical treatments that can work against individual recovery. Insurers are recommended to develop product- and non-product-related support for mental as well as physical health covers; and offer solutions with an emphasis on early prevention and collaboration with employers (Chen and Wang, Swiss Re Institute 2021)[19] – including making active use of what nature can contribute.

We could achieve USD 60 billion annual savings by 2030 if the financial impact of mental health conditions was reduced by just 1% through time spent in nature.

Cardiovascular disease

CVD is an extremely costly disease.

Bloom et al. (2011) estimated the global cost of cardiovascular disease (CVD) at USD 863 billion in 2010; with an expected increase to USD 1044 billion by 2030.[20] Whilst difficult to quantify the exact effect, it is widely understood that immersion in nature helps prevent or postpone cardiovascular disease. This is particularly the case for those in lower income brackets and difficult social-economic conditions. A number of global studies have explored the impact of nature on CVD mortality and morbidity, of which the examples referenced below are only a selection.

Control studies show improved CVD markers with access to nature.

Plans et al. (2019) analysed the relationship between green space density and cardiovascular risk factors in Madrid. They found associations between the density of green areas within 300–500m from inhabitants with high cholesterol and diabetes, and an association between the density of green areas within a 1500m buffer with hypertension. All these associations were significant only in women. In Finland, Lanki et al. (2017) conducted a field experiment on the acute effects of visits to urban green spaces on cardiovascular physiology on a small sample size of women. Lower blood pressure was noted during observations, alongside a lower heart rate and fewer incidents of heart rate variability, when compared to visits to the city centre. In green environments, the heart rate decreased during the visit. The associations between environmental and cardiovascular health indicators weakened slightly after particulate air pollution and noise were factored in.

Seao et al. (2019) found a correlation between those living in South Korean urban areas with greater green space coverage and a reduced risk of CVD. Xu et al. (2017) examined the association between area-level green space and adult mortality in Hong Kong. City green spaces with higher normalised different vegetation index (NDVI) levels are associated with less CVD and lower incidence of diabetes, and in this case with stronger associations among men and low-income individuals.

[19] J. Chen, V. Wang 2021. *Mental health in Japan. An opportunity for insurance to help close the protection gap.* Swiss Re Institute 2021.

[20] D.E. Bloom, E.T. Cafiero, E.T., E. Jané-Llopis, S. Abrahams-Gessel, L.R. Bloom, S. Fathima, A.B. Feigl, T. Gaziano, M. Mowafi, A. Pandya, K. Prettner, L. Rosenberg, B. Seligman, A.Z. Stein, C. Weinstein 2011. *The Global Economic Burden of Noncommunicable Diseases. Geneva: World Economic Forum*

Green spaces have a role to play especially for CVD prevention.

Yeager et al. (2018) showed that US residential green spaces are associated with lower sympathetic nervous system activation, reduced oxidative stress and higher angiogenic capacity regardless of age, gender, race, smoking status, neighbourhood disadvantage, statin use and roadway exposure. In Canada, Ngum et al. (2016) demonstrated the importance of green spaces for the prevention of cardiovascular morbidity and diabetes, reporting that those areas with a greater distance to green spaces had a cardiovascular mortality prevalence rate (PRR) 11% higher, and a higher risk of diabetes (PRR 9%) than those nearest to the green spaces. Silveira and Junger (2018) looked at the link between green spaces and mortality from CVD in the city of Rio de Janeiro and found a 6.7% and 4.7% reduction in ischemic heart disease and cerebrovascular disease, respectively. In the stratified analysis, the protective effect of green spaces on mortality due to ischemic heart disease was observed in the greenest sectors of all strata, and it was higher for those at a lower socioeconomic level. For mortality due to cerebrovascular diseases, the protective effect was verified only for the greenest sectors and at the lowest socioeconomic level.

We could achieve USD 10 billion in annual savings by 2030 if the financial impact of heart disease was reduced by just 1% through time spent in nature.

Air quality

Air pollution is a significant driver of morbidity and mortality.

Air pollution is one of the major environmental risk factors for the global burden of disease between 1990–2015, contributing to trachea, bronchus and lung cancer, chronic obstructive pulmonary disease (COPD), ischemic heart disease and stroke.[21] Despite success in reducing some industrial air pollutants in certain Organisation for Economic Co-operation and Development (OECD) countries, air pollution remains a global issue, irrespective of the polluting source, eg industry, traffic and transport, or households. Babatola (2018) reported increased rates of Disability Adjusted Life Years (DALYs) due to air pollution in regions of South-East Asia, Africa and the Eastern Mediterranean, in growing as well as ageing populations by the expansion of heavy industry. According to Cohen et al. 2017, exposure to PM2.5[22] alone caused 4.2 million deaths and 103.1 million DALYs in 2015 – which accounts for 7.6% of all global deaths or 4.2% of all global DALYs, with almost 60% of these occurring in South-East Asia.[23] Furthermore, exposure to ozone caused an additional 254 000 deaths and a loss of 4.1 million DALYs from COPD in 2015.[24]

Green spaces act as natural air filters against air pollutants.

Green spaces filter pollutants such as particulate matter from the air, thereby reducing health risks for local residents. Jaafari et al. (2020) showed the positive effects for the city of Tehran, where urban green spaces had a significant mitigating effect on air pollution (main indicator PM2.5) and mortality from respiratory diseases.

[21] S.S. Babatola 2018. *Global burden of diseases attributable to air pollution.* Journal of Public Health in Africa 2018 Dec 21, 9 (3):813.

[22] „PM' is the term for particulates matter, „a mixture of solid particles and liquid droplets found in the air." PM 2.5 are „fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller". They can go deep into lungs and bloodstream and cause harm. See www.epa.gov/pm-pollution/particulate-matter-pm-basics

[23] According to the definition of the World Health Organisation WHO, DALY is a „measure that combines years of life lost due to premature mortality and years of life lost due to time lived in states of less than full health, or years of healthy life lost due to disability. One DALY represents the loss of the equivalent of one year of full health. Using DALYs, the burden of diseases that cause premature death but little disability (such as drowning or measles) can be compared to that of diseases that do not cause death but do cause disability (such as cataract causing blindness)." www.who.int/data/gho/indicator-metadata-registry/imr-details/158

[24] A.J. Cohen, M. Brauer, R. Burnett et al. *Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study* 2015. Lancet 2017; 389:1907-18

The research concluded that maximising green space and its cohesion and minimizing fragmentation and green space perimeter can contribute to a reduction of air pollution and consequently to a lower mortality rate.[25] Datzmann et al. (2018) demonstrated a relationship between outdoor air pollution, green spaces and cancer incidence in Saxony. A 10% increase in NDVI (normalised different vegetation index) protected the majority of the reviewed population from oral and throat cancer and from non-melanoma skin cancer (NMSC). Colon cancer was not affected by any of the exposures.[26] Hu et al. (2008) noted a high risk of stroke-related mortality in areas of Northwest Florida with low income levels, high levels of air pollution and low exposure to green spaces.[27]

Nowak et al. (2014) analysed the effects of trees and forests on air quality and human health for the US as a whole, relating it to health costs, and found a causal relationship between air pollution reduction, trees and improved health. The total amount of pollutants removed from trees and forests in 2010 was 17.4 million tons, representing a reduction in human health costs of USD 6.8 billion.[28]

For the US, it has been estimated that USD 6.8 billion in healthcare savings (in 2010) would be achieved from the benefits of fresh air produced by forests and woodland (Novak et al).

Heat

Climate change is accelerating the effect of heat events on mortality.

Green spaces offer cooler areas during heat waves, particularly in urban or semi-urban areas, which leads to a reduction of mortality during or directly after heat waves. Vicedo-Cabrera et al. (2021)[29] assessed the burden of heat-related mortality for 732 locations in 43 countries between the years 1991–2018. Across all countries, they found that more than a third of heat-related deaths during summer months can be attributed to climate change. Increased mortality is evident on every continent. With climate change accelerating, negative impacts on population health will grow, as recently seen in the 2021 'heat dome' in Western Canada. Any urban climate change mitigation and adaption strategies need to examine these relationships and invest in green spaces.

Heat wave mortality was reduced in urban areas with green spaces.

Burkart et al. (2016) analysed the modification of heat-related mortality in an older, urban population, by vegetation (city green) and water proximity (city blue) in Lisbon, where both factors were associated with reduced heat-related mortality. The research shows associations between mortality and a 1°C increase in a universal thermal climate index (UTCI) above the 95th and 99th percentile in areas with high NDVI and in areas located closer to the Atlantic.[30] Xu et al. (2013) showed differences in the effect of heat waves on mortality according to socio-demographic and urban landscape

[25] S. Jaafari, A.A. Shabani, M. Moeinaddini, A. Danehkar, Y. Sakieh *Applying landscape metrics and structural equation modeling to predict the effect of urban green space on air pollution and respiratory mortality in Tehran.* Environmental Monitoring and Assessment 192, 412 2020. https://doi.org/10.1007/s10661-020-08377-0

[26] T. Datzmann, I. Markevych, F. Trautmann, J. Heinrich, J. Schmitt, F. Tesch. *Outdoor air pollution, green space, and cancer incidence in Saxony: a semi-individual cohort study.* BMC Public Health. 2018 Jun 8;18(1):715. doi: 10.1186/s12889-018-5615-2. PMID: 29884153; PMCID: PMC5994126.

[27] Z. Hu, J. Liebens, K.R. Rao *Linking stroke mortality with air pollution, income, and greenness in northwest Florida: an ecological geographical study.* Int J Health Geogr. 2008 May 1;7:20. doi: 10.1186/1476-072X-7-20. PMID: 18452609; PMCID: PMC2396612.

[28] D.J. Nowak, S. Hirabayashi, A. Bodine, E. Greenfield *Tree and forest effects on air quality and human health in the United States.* Environmental Pollution 193 2014 119-129.

[29] A.M. Vicedo-Cabrera, N. Scovronick, F. Sera, et al. *The burden of heat-related mortality attributable to recent human-induced climate change.* Nat.Clim.Chang. 11, 492–500 (2021). https://doi.org/10.1038/s41558-021-01058-x

[30] K. Burkart, F. Meier, A. Schneider, S. Breitner, P. Canário, M.J. Alcoforado, W. Endlicher. *Modification of heat-related mortality in an elderly urban population by vegetation (urban green) and proximity to water (urban blue): evidence from Lisbon, Portugal.* Environ Health Perspect, 124: 927-34, 2016.

characteristics in Spain. The effect of three consecutive hot days was a substantial 30% increase in total mortality. The heterogeneity of this effect was observed in all census groups. The influence of heat on mortality was higher in the census reports with a high percentage of those living in old buildings, craftsmen, and residents with little green in their surroundings. After three consecutive hot days, mortality doubled in the most heat-sensitive groups. Living in areas that were not perceived by their inhabitants as lacking in green space showed a protective effect during heat events.[31]

Son et al. (2016) analysed a similar association between urban vegetation and heat-related mortality in Seoul. The association between all-cause mortality and a temperature increase of 1°C over the 90th percentile (25.1°C) (the "heat effect") was highest in areas with low NDVI. The estimated health risks showed similar effects depending on gender and age. The results indicate a higher mortality effect of high temperatures, in areas with lower vegetation in Seoul.[32]

Gronlund et al. (2016) shed light on the vulnerability to extreme heat based on socio-demographic characteristics and area green spaces, among older people in Michigan, over the period of 1990-2007. The probability of cardiovascular mortality during extreme heatwaves (99th percentile threshold) was higher in unmarried persons, and persons in postal codes with a high share of non-green areas.[33]

Consequently it is evident that greener cities can reduce heat-island effects that cause early mortality or other negative health impacts.[34]

Studies have demonstrated reductions in heat island effects from parks and green spaces.

Green roofs, parks, trees and vegetation are measures to reduce the heat-island effects. Aram et al. (2019) conducted a literature analysis of the overall cooling effects of urban green spaces (hence not related to health impacts).[35] They concluded that large parks (>10 hectares) lead to a 1–2°C temperature reduction that extended over a 350m distance from the park boundary. Only one study has looked at small parks, demonstrating that polygonal-types of small green spaces have a stronger cooling effect than other types, and that mixed green spaces of over 2000 m3 can reduce 1°C of the surrounding temperature (Park et al. 2017).[36] With a particular focus on London's parks, Doick et al. (2014) discovered a cooling effect of up to 4°C on distances up to 440m from a park on single warm, summer nights, when the cooling was most needed.[37] The US Environmental Protection Agency (EPA) (2018) demonstrated the multiple environmental and health benefits of green roofs for Kansas City, Missouri, with a special focus on heat effects. The study showed that the cooling effect of green roofs – indicated by the temperature difference between the rooftop surface and the surrounding air measured in watts per square meter of the surface area ("W/m2") is, on an annual average, almost two times stronger than for dark roofs. For the average of the summer season, the cooling effect of green roofs is up to three times stronger and for the daily peak average in summer the effect is four times as strong. Furthermore, due to their insulating properties, green roofs enhance energy saving and reduce water consumption, if they are installed such that they can retain rainwater and transport this into cisterns. If green roofs were used for the whole of Kansas City, they could deliver 84% of the city's annual irrigation demand and annually save USD 54 000 in

[31] Y. Xu, P. Dadvand, J. Barrera-Gómez, C. Sartini, M. Marí-Dell'Olmo,C. Borrell, M. Medina-Ramón, J. Sunyer, X. Basagana. *Differences on the effect of heat waves on mortality by sociodemographic and urban landscape characteristics.* J Epidemiol Community Health. 2013 Jun;67(6):519-25. doi: 10.1136/jech-2012-201899. Epub 2013 Feb 26. Erratum in: J Epidemiol Community Health. 2013 Jul;67(7):624. PMID: 23443960.

[32] J.Y. Son, K.J. Lane, J.T. Lee, M. Bell *Urban vegetation and heat-related mortality in Seoul, Korea.* Environ Res. 2016 Nov;151:728-733. doi: 10.1016/j.envres.2016.09.001. Epub 2016 Sep 17. PMID: 27644031.

[33] C.J. Gronlund; V.J. Berrocal, J.L. White-Newsome, K.C. Conlon, M.S. O'Neill. *Vulnerability to extreme heat by socio-demographic characteristics and area green space among the elderly in Michigan,* 1990-2007. Environ Res. 2015 Jan;136:449-61. doi: 10.1016/j.envres.2014.08.042. Epub 2014 Nov 25. PMID: 25460667; PMCID: PMC4282170.

[34] The Lancet 2020. N. Watts et al. *The 2020 report of The Lancet Countdown on health and climate change: responding to converging crises.* December 02, 2020. Doi.org/10.1016/S0140-6736(20)32290-X

[35] F. Aram, E. Higueras García, E. Solgi, S. Mansournia 2019. *Urban green space cooling effect in cities.* Heliyon. Volume 5, Issue 4, 2019, e01339, ISSN 2405-8440, https://doi.org/10.1016/j.heliyon.2019.e01339.

[36] J. Park, J. Hyun Kim, D.K. Lee, C.Y. Park, S.G. Jeong 2017. *The influence of small green space type and structure at the street level on urban heat island mitigation.* Urban Forestry & Urban Greening, 21 January 2017, pp.203-212

[37] K.J. Doick, A. Peace, T.R. Hutchings 2014. *The role of one large greenspace in mitigating London's nocturnal urban heat island.* Science of The Total Environment. Volume 493, 2014,Pages 662-671, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2014.06.048.

municipalwater costs.[38] Furthermore, the US Environmental Protection Agency (EPA) has made reference to studies which found that tree shaded surfaces may be 11–25°C cooler than the peak temperatures of unshaded materials.[39]

More research is needed to determine all variables that impact the extent of green cooling.

Evapotranspiration reduces peak summer temperatures by 1–5°C.[40] McPherson et al. (2005) calculated the benefits of urban trees versus their costs for five US cities, taking into consideration heat-island mitigation, but also their stormwater protection service. While cities spend USD 13-65 annually per tree, benefits ranged from USD 31 to USD 89 per tree. For every dollar invested in urban tree management, annual benefits ranged from USD 1.37 to USD 3.09.[41]

Nevertheless, urban landscape planning studies agree that more knowledge is needed regarding the variables that impact the extent of cooling through and beyond green spaces. To successfully reduce the impact of heat, inner cities will need more than green spaces – including, special shelters, different tarmacs (composition and colour), alternative building compositions and strategic placement in conjunction with air flow corridor management.[42]

Green spaces themselves need to be optimised in order to achieve maximum impact for urban heat reduction. The diversity of tree species needs to be enlarged. According to Wang et al. (2021), mean tree crown width is positively correlated with the cooling range in summer and autumn, while tree density within urban green spaces is negatively correlated with the cooling range in winter.[43] Furthermore, the plants that are used need to be resilient against climate change and extreme weather such as longer periods of droughts, flash floods, windstorms or winter storms and heavy snow fall. Potential counter effects on health also need to be considered, such that certain plants may increase certain allergies (pollen) or may provide a habitat for species that may carry diseases (gnats, ticks).

Urban trees cool, clean the air and provide space for relaxation – reducing heat and respiratory conditions and improving mental health.

[38] U.S. Environmental Protection Agency 2018. *Estimating the environmental effects of green roofs: A case study in Kansas City, Missouri.* EPA 430-S-18-001. www.epa.gov/sites/production/files/2018-09/documents/greenroofs_casestudy_kansascity.pdf

[39] H. Akbari, D. Kurn et al. 1997. *Peak power and cooling energy savings of shade trees.* Energy and Buildings 25:139–148.

[40] J. Huang, H. Akbari, H. Taha. 1990. *The Wind-Shielding and Shading Effects of Trees on Residential Heating and Cooling Requirements.* ASHRAE Winter Meeting, American Society of Heating, Refrigerating and Air-Conditioning Engineers. Atlanta, Georgia. D. Kurn, S. Bretz, B. Huang, and H. Akbari. 1994. The potential for reducing urban air temperatures and energy consumption through vegetative cooling. ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy. Pacific Grove, California.

[41] G. McPherson, J.R. Simpson, P.J. Peper, S.E. Maco, Q. Xiao 2005. *Municipal Forest Benefits and Costs in Five US Cities.* Journal of Forestry. December 2005. 411-419

[42] C. Heaviside, H. Macintyre, S. Vardoulakis. *The Urban Heat Island: Implications for Health in a Changing Environment.* Curr Envir Health Rpt 4, 296–305 (2017). https://doi.org/10.1007/s40572-017-0150-3

[43] X. Wang, M. Dallimer, C.E. Scott C.E, W. Shi, J. Gao. *Tree species richness and diversity predicts the magnitude of urban heat island mitigation effects of greenspaces.* Sci Total Environ. 2021 May 20;770:145211. doi: 10.1016/j.scitotenv.2021.145211. Epub 2021 Jan 17. PMID: 33513510.

Figure 1: Co-benefits of heat islands mitigation strategies

	Green roofs	Trees and vegetation	Pavement	Cool roofs
Air quality	✓	✓	✓	✓
Energy use	✓	✓	✓	✓
Greenhouse gas emissions	✓	✓	✓	✓
Human health and comfort	✓	✓	✓	✓
Nighttime visibility			✓	
Quality of life	✓	✓	✓	✓
Safety			✓	
Stormwater management	✓	✓		
Tire noise			✓	
Water quality	✓	✓		

Source: U.S. Environmental Protection Agency. www.epa.gov/heatislands/using-green-roofs-reduce-heat-islands

Green roofs are insurable

Green roofs offer many advantages to building owners and occupiers, the general public and the environment. These include better insulation, reduced power consumption, stormwater retention, improved air quality and a biodiverse environment offering aesthetic diversity. However, green roofs may introduce property considerations and concerns that owners and occupiers should be aware of when reviewing their property and business risks. Green roofs can be insured.

1 Potential for water leakage damage

The irrigation pipework may be susceptible to freezing. Leaks in waterproofing membranes due to root growth or temperature fluctuations may expose the underlying roof structure to damage or corrosion. Drainage systems may become blocked by soil and vegetation. These risks are particularly relevant in the construction phase. **Loss Prevention Tips:** Penetrations in the roof should be minimised. It is important to include leak detection systems below the waterproofing membrane. Gutters should be sized to accommodate both rainfall and irrigation runoff with regular maintenance, and with specific inspection points included. Consider the impact of roof gradient on the density of growth media and its propensity to shift or slide during heavy rain events.

2 Fire load

Green roofs and their supporting components (eg vegetation and waterproofing membrane) typically add combustible loading to a roof and increase the potential for ignition from exposing fires or other ignition sources. In some cases, the design of a green roof may encompass space for recreational activities, introducing ignition sources such as lighting, electrical installations, barbecues/grills, and smoking. **Loss Prevention Tips:** Limit the overall fire risk by maintaining adequate moisture content of vegetation, regular removal of dead vegetation, and careful design and placement of non-combustible fire breaks. Include manual firefighting equipment such as fire hydrants, fire hose reels, and portable fire extinguishers, along with access provisions for the fire brigade. Potential ignition from electrical equipment, smoking, or other sources should be identified and carefully managed.

3 Susceptibility to collapse

Green roofs introduce live loads associated with landscaping, precipitation, induced saturation due to irrigation, and periodic replacement of new soil and growth of vegetation. **Loss Prevention Tips:** The load carrying ability of concrete roofs versus all other types (eg, long span steel) should be considered over the roof lifecycle. Some roofs may have increased susceptibility to deformation over time, affecting the operational efficiency of certain components that originally functioned properly. Future changes may affect the structural integrity and should undergo formal review. Concrete roofs are generally more resilient than other roofs to changes that increase live loading.

4 Damage from natural hazards

Green roofs are susceptible to natural hazard perils such as seismic forces and wind uplift pressures. Vegetation or potentially the entire roof system may be damaged, requiring replacement. **Loss Prevention Tip:** The system, including any moisture/root barriers, should be properly secured to structural elements (growth media should not be relied upon). Green roofs should not generally be installed in areas with elevated wind exposures such as coastal areas subject to hurricanes.

Source: J. Bukofsky and A. Mehta, 2020, Swiss Re Corporate Solutions: Sustainability Series: Green Roofs | Swiss Re[44]

[44] Online available at https://corporatesolutions.swissre.com/insights/knowledge/sustainability-series-green-roofs.html

Noise

A significant proportion of urban dwellers are exposed to noise pollution with health implications.

According to the European Environmental Agency (EEA) (2020), in Europe alone, 20% of the population or more than 100 million people are exposed to noise levels which are seen to be harmful to their health. EEA reported annual figures of 48 000 new cases of ischaemic heart disease, 12 000 premature deaths, 22 million cases of chronic high annoyance in light of extreme noise, 6.5 million cases of chronic high sleep disturbance and 12 500 school children suffering reading impairment all directly linked to long-term high noise exposure. Geographically, the EEA identified a clear urban-rural divide. Roughly 70% of the people suffering from high chronic noise annoyance, 65% people suffering from high sleep disturbance, 70% of the ischaemic heart disease group, 71% of premature deaths and 77% of those suffering cognitive impairment were all urban residents (EEA 2020:51).[45]

The EEA also identified that anthropogenic noise "causes a range of physiological and behavioural responses in terrestrial and marine wildlife, which can lead to reduced reproductive success, increased mortality risk and emigration, resulting in decreased population densities." Effects started to appear at levels as low as 40 decibels (for terrestrial animals). Impacts also depended on noise frequency and type.

Traffic, transport and industry are the largest sources of noise pollution.

The EEA estimated that 1 million years of life are lost every year from the negative health effects of noise, amounting to a total cost between 0.2% to 2% of the EU Gross Domestic Product (GDP).[46] Road traffic noise is seen as the most dominant source of noise pollution, with 113 million people affected by long-term day-evening-night traffic noise levels of at least 55 decibels. Another 22 million are exposed to high levels of railway noise, 4 million to high levels of aircraft noise and just under 1 million to high levels of noise caused by industries.[47]

Green buffer zones can reduce noise pollution.

The US National Agroforestry Center has developed a scheme for planting (green) buffer guidelines to reduce highway noise close to outdoor recreation areas, based on experimental studies. These areas should not be exposed to noise above 65 decibels. A 30m wide planted buffer reduces noise by 5 to 8 decibels. A barrier in such a buffer – eg a landform – can increase effectiveness and deliver 10 to 15 decibel reduction per 30m wide buffer with 3.76m high landform.[48]

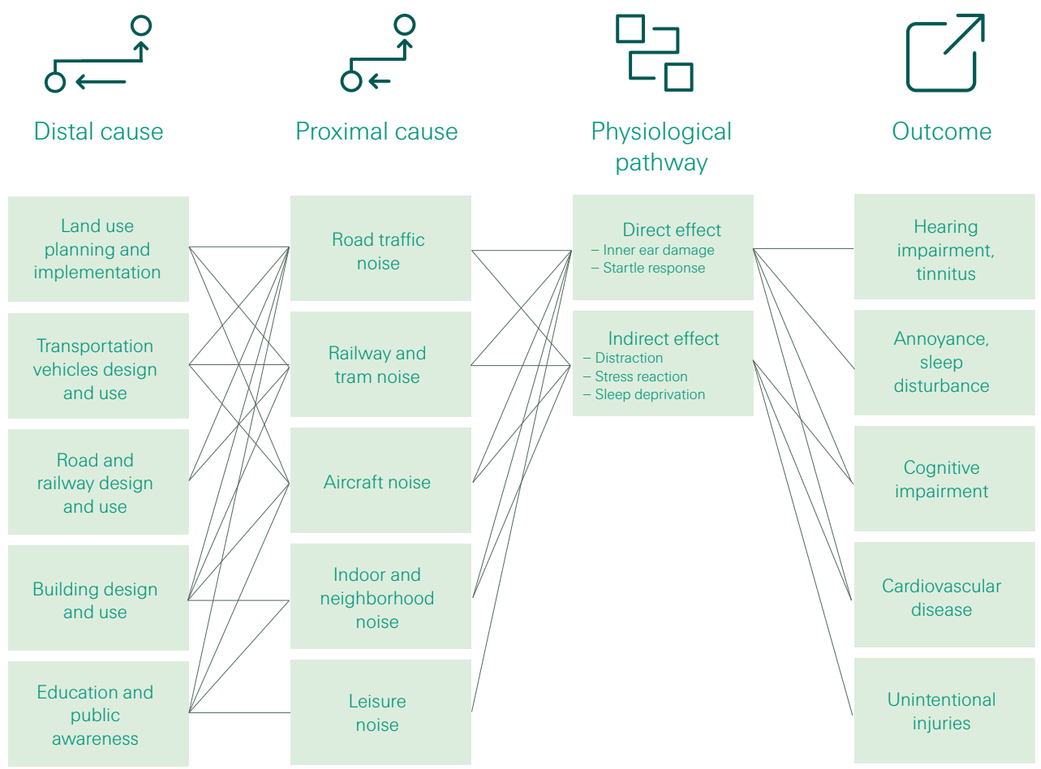
Green spaces can be noise reducers with co-benefits.

Ow and Gosh (2017) conducted experimental noise and vegetation studies in cities. Traffic noise was reduced by 50% or 9–11 decibels when vegetation was enhanced from a minimal to moderate planting intensity (roughly 5m depth of vegetation barrier). Dense planting intensity did not bring substantial further noise reduction. Synthetic barriers were found to be inferior, not just in regard to absolute values of noise, but also psychologically.[49]

Investment into green areas, foremost in cities, can only be a part of solutions to reduce noise exposure. In fact, the EEA recommends measures at the noise source (eg traffic management, road surface and rail track measures) as well as on the path (noise barriers, insulation). Further measures such as education and communication (sustainable mobility), urban planning and infrastructure change – and availability of quiet and green areas (EEA 2020:76), can also be beneficial.[50]

45 2020 EU GDP in current USD was 15.2 trn. data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=EU
46 European Environmental Agency 2020. *Environmental Noise in Europe*. EEA Report No 22/2019. Luxembourg.
47 see footnote 45
48 USDA National Agroforestry Center. Conservation buffers. Buffers for noise control. See www.fs.usda.gov/nac/buffers/guidelines/6_aesthetics/4.html
49 L.W. Ow, S. Ghosh 2017. *Urban cities and road traffic noise: Reduction through vegetation*. Applied Acoustics, Volume 120, 2017, Pages 15-20, ISSN 0003-682X, https://doi.org/10.1016/j.apacoust.2017.01.007
50 see footnote 45

Figure 2: Relationship between noise and health



Source: World Health Source: Burden of disease from environmental noise. Kim R., WHO Regional Office for Europe European Centre for Environment and Health Bonn, Germany. 25 May 2011.

Forestry Insurance

Forestation is currently being discussed in conjunction to mitigating climate change, because of the carbon sequestration service of forest ecosystems. Governments and businesses have made a series of formal commitments to invest into forestry which is not for the purpose of generating timber value.

Forestry risks are usually insured for commercially and professionally managed forest plantations, which are a fraction of all forests globally. These forests are exposed to a wide range of weather related, biological, market, and country related risks. To deal with these risks effectively, owners need to have sound risk management practices in place. The most usual insured forestry risks are fire, windstorm, ice/snow/hail, flood, and earthquake risks. Due to global warming, it will become more important to look at drought risks as well.

Windstorm can affect large areas and can result in severe forestry losses. The degree of damage is mainly influenced by wind speed, tree species, tree height, soil conditions, additional snow weight, topography and recent thinning work done.

Fire is another serious risk, and 95% of forest fires are caused by human activity. Fire propagation is mainly influenced by topography, wind speed, availability of combustible material, precipitation and humidity. Fire severity depends on fuel loads, weather conditions, and cause of ignition. To provide insurance coverage, underwriters need to understand how the forest owners' fire detection systems work and what firefighting capabilities and equipment are available.

In contrast to other agricultural crop types, forest insurance is a niche. Forests have long rotation periods from 10 to 200 years, depending on tree species, geography, and demand for timber. The related capital is bound. Despite the long exposure periods, only a small share of the world's forests is insured. Forestry insurance typically covers timber only up to the point when the trees are harvested. The insured timber value depends on the tree species, age, yield class and soil type. It is usually between USD 1 000 to 5 000 per hectare.

Similarly, and in the context of this publication, the life and health related benefits of trees and other plants are a call to newly build or increase, where possible, urban or peri-urban parks. All these newly planted forests will also be exposed to natural catastrophes. Potentially, these new or extended areas may qualify for insurance.

While there will not be a loss history in many of these areas, underwriters and risk managers will carefully check these criteria:

- Appropriate technology, equipment, installations, and risk management plans and processes available to protect the trees and plants against fire or drought or other critical situations
- Clear ownership and management responsibilities established
- Skilled and experienced forest workers or urban gardeners available to take care for the plants
- Comprehensive and solid financials
- Adherence to local and regional conservation and biodiversity policies, avoidance of monocultures
- Basic information such as tree species, annual growth rates, potential rotation periods, silvicultural measurements
- Weather history, potentially loss and exposure data

For underwriting it is important to specifically look at increased (re-)planting costs in dense urban areas, potential for loss of service (=loss of plant life), cost for debris removal, replanting or re-establishment for infrastructure, and loss adjustment costs. Extensions would need to be defined and priced into insurance. Third party liability losses, such as trees falling on neighbouring properties and biological losses (due to fungi, insects, rot), are typically excluded.

Source: P. Welten et al 2015. Forest Insurance: A largely untapped potential. Swiss Re Zurich.[51]

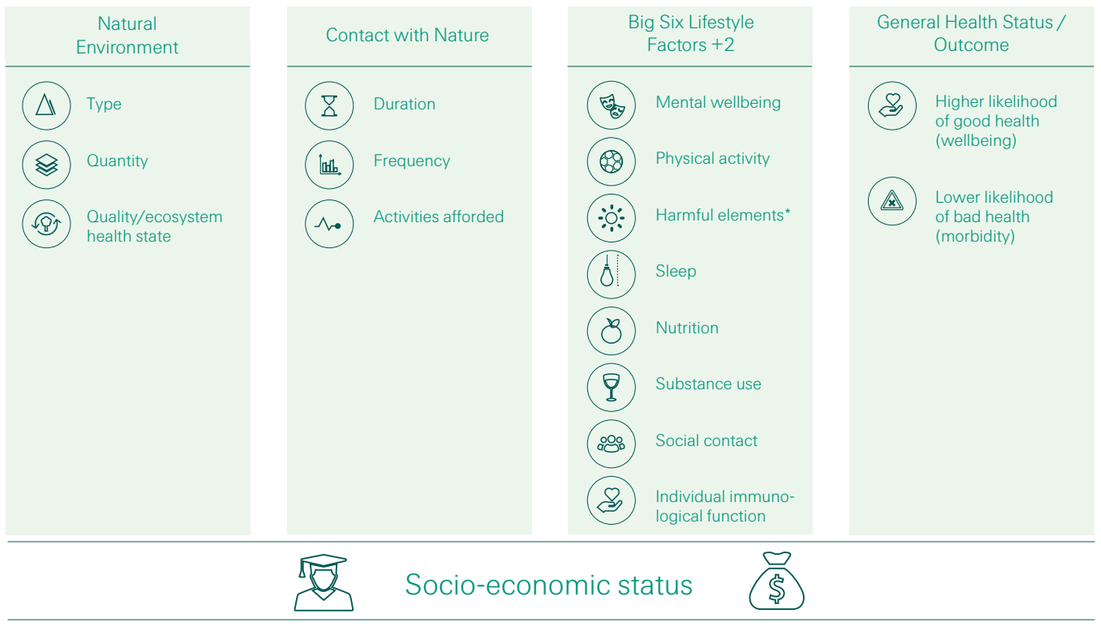
[51] Online available at www.swissre.com/Library/forestry-insurance-a-largely-untapped-potential.html

Integration of nature into the concept of individual health factors

Green spaces provide benefits to the 'Big Six' lifestyle factors.

Adapted from Hartig et al. 2014[52], Wheeler et al. 2015 provide a conceptual model to describe and model pathways between different measures for nature and general health.[53]As the previous chapter highlights, geographically differentiated socio-economic and urban/rural variables can help explain the variation in health outcomes. Factors positively influenced by nature include physical activities (including time spent in nature); social contacts; mental well-being; air pollution; heat exposure (depending on the occupation); and individual immunological resilience (figure 3). These are in line with the „The Big Six" Lifestyle Factors relevant for individual health that Swiss Re has identified, which matter most in an assessment of biological causation pathways.[54,55] Swiss Re defines the health relevant risks that surrounds us as environmental risks. Typically, they are external physical, chemical, biological, and work-related components that affect individual health. More broadly, factors such as pollution, light, radiation, noise, land use patterns, work environment, as well as climate change can be included.[56] Nature – the natural environment, green spaces – plays a strong role in prevention and in reducing the impact of these surrounding risks on an individual's health. Activities which are undertaken with such an aspiration are nature-based health related solutions.

Figure 3: Swiss Re's „Big Six" Lifestyle Factors relevant for individual health in their interconnection to nature



* eg exposure to air pollution, heat waves; frequency and intensity

Source: Wheeler et al. 2018, Hartig et al. 2014, integrating Swiss Re 2020's „The Big Six" Lifestyle Factors relevant for individual health

52 T. Hartig, R. Mitchell, S. de Vries, H. Frumkin *Nature and health.* Annu Rev Public Health. 2014;35:207–28.
53 B.W. Wheeler, R. Lovell, S.L. Higgins et al. *Beyond greenspace: an ecological study of population general health and indicators of natural environment type and quality.* Int J Health Geogr 14, 17 (2015). https://doi.org/10.1186/s12942-015-0009-5
54 J. Schoonbee, R. Barwick, M. Ducker 2020. Swiss Re. *Lifestyle risk factors: A new frontier for risk assessment.*
55 Also see „The Big Six" Lifestyle Factors | Swiss Re
56 F. Rechfeld, H. Liu 2021. Swiss Re. *Can we underwrite our surroundings? The challenges and opportunities of environmental risk factors.*

Individual health is a result of many complex and interconnected risk factors that also interact with each other. Sleep affects physical activity. Physical activity influences nutrition and food choices (Swiss Re 2020). Noise at night affects sleep (WHO Europe 2009, Halperin 2014)[57], as does high temperatures (Obradovich et al 2017)[58]. Greener environments around residences are less noisy, and reduce temperature (Aram 2019, Ennos 2015).[59] Proximity and access to green areas increases incentives for physical activity.

With regards to the latter point, Jenkin et al. (2015) investigated the role of the neighbourhood in children's weight-related behaviour and body mass index in New Zealand.[60] Physical activity, and distance from greater access to green spaces were significantly associated, also if lower high-sugar drink consumption was the case. Lachowycz and Jones (2013) examined associations between access to green spaces, walking and lower mortality.[61] Clear evidence of better access to green spaces combined with higher reported leisure walking was shown; but evidence for walking and lower mortality only revealed itself in the most disadvantaged areas. Coombes et al. (2010) described the relationship between physical activity, obesity, and accessibility to and use of green spaces in Bristol.[62] Respondents who lived closest to green spaces were more likely to achieve the recommended physical activity and less likely to be overweight or obese. The association with physical activity, but not with overweight or obesity, persisted even after adjustment for the characteristics of the respondents, the social disadvantages of the area and a number of characteristics of the neighbourhood.

Green spaces encourage physical activity, a key health driver.

The research suggests that providing good access to green spaces in urban areas can help to promote physical activity among the population. Physical activity, in turn, can reduce stress and support the prevention of cardiovascular diseases. Increased physical activity can also lead to less obesity, which can result in better mental health and be associated with lower general mortality. In an eight-year cohort study among more than 100 000 women in the US, James et al. (2016) proved the interconnectedness of different individual health factors and time spent in nature by examining the prospective association between residential greenness and mortality. Women who live in homes with more vegetation in the neighbourhood had a 12% lower rate of all-cause non-accidental mortality than those in areas with less vegetation. Respiratory disease-related mortality was 34% lower and cancer-related mortality was 13% lower. Improved mental health (lower depression levels) explained almost 30% of the benefit from green neighbourhoods. According to the authors, social engagement, higher physical activity and lower exposure to air pollution also play important roles. Other mortality risk factors such as age, socio-economic status, ethnicity and smoking behaviour were controlled for in this instance.[63] The understanding of these causal effects is important for life & health insurance loss modelling and underwriting.

57 WHO Europe recommends noise levels at night to be below 40 decibels in order to avoid harm. World Health Organisation Europe 2009. Night noise guidelines for Europe. Denmark 2009. www.euro.who.int/__data/assets/pdf_file/0017/43316/E92845.pdf. D. Halperin. Environmental noise and sleep disturbances: A threat to health? Sleep Sci. 2014 Dec;7(4):209-12. doi: 10.1016/j.slsci.2014.11.003. Epub 2014 Nov 15. PMID: 26483931; PMCID: PMC4608916.
58 N. Obradovich, S.C. Migliorini, M. and J.H. Fowler. *Nighttime temperature and human sleep loss in a changing climate.* Sci Adv 2017, 3. May 26, 2017, doi: 10.1126/sciadv. 1601555. The authors have accessed data from 765'000 US health survey respondents from 2002 to 2011, look at the relation of extreme weather and reports of insufficient sleep, and project a view on nighttime disturbance towards the end of the 21st century. Largest effects are observed during the summer and among both lower-income and elderly respondents. As stated by the authors, the study „represents the largest investigation of the relationship between sleep and ambient temperature and provides the first evidence that climate change may disrupt human sleep."
59 R. Ennos. *Can trees really cool our cities down?* December 2015. Online article in theconversation.com/can-trees-really-cool-our-cities-down-44099 2015. A. Farshid, E. Higueras García, E. Solgi, S. Mansournia Urban green space cooling effect in cities. Heliyon, Volume 5, Issue 4, 2019, e01339, ISSN 2405-8440, https://doi.org/10.1016/j.heliyon.2019.e01339.
60 L.J. Gabrielle, L.P. Amber, G. Bentham, P. Day, S. Kingham 2015. *Neighbourhood Influences on Children's Weight-related Behaviours and Body Mass Index.* AIMS public health, Vol. 2, no. 3, August 2015, pp. 501–515.
61 K. Lachowycz, A.P. Jones 2014. *Does walking explain associations between access to greenspace and lower mortality?* Social Science & Medicine, Vol. 107, April 2014, pp. 9–17.
62 E. Coombes, A.P. Jones, M. Hillsdon. 2010. The relationship of physical activity and overweight to objectively measured green space accessibility and use. Social Science & Medicine, Vol. 70, no. 6, March 2010, pp. 816–822.
63 P. James, J.E. Hart, R.F. Banay, F. Laden. 2016. *Exposure to greenness and mortality in a nationwide prospective cohort study of women.* Environ. Health Perspect. 124:1344–1352; http://dx.doi.org/10.1289/ehp.1510363

Integrating ‘green’ variables into L&H insurance models remains challenging.

What sort of green are we seeking to achieve?

Planners and architects are incorporating more green places and spaces in their work. The construction and operation of green spaces can be insured against a variety of risks. Health insurance can promote nature-based prevention activities that reduce health costs. However, the integration of nature into life & health insurance risk models remains a challenge. The ‚nature‘ variables that matter need to be defined, and time spent in nature, as well as proximity to nature, need to be systematically recorded to build time series long enough to connect to health indices.

Key will be standardising definitions of ‘nature’ and its effects.

The re/insurance industry needs improved and standardised means of measuring ‚nature‘ and time spent in nature to better explain the positive effects of it, on health. This will also support differentiated views in developing insurance policies, including incorporating specific nature-related preventive or therapeutic measures.[64] Opportunities for physical activity; reduction of air pollution; reduction of city heat islands; and opportunities for social engagement will all improve health. Negative effects of certain plants will need to be considered (allergens, invasive species, avoidance of pathogen reservoirs) in planning, as well as the impact of climate change – warming and precipitation changes – on plant health. Here, it will matter where certain plants are placed, especially in urban environments.[65]

Looking ahead: the 2021–2030 UN decade of ecosystem restoration will be closely linked to health issues

Green spaces should be part of the ‘building back better’ agenda.

The UN has called on the international community over the current decade to reverse ecosystem degradation and to close the biodiversity investment gap identified by Deutz et al in 2020 as being larger than USD 700bn. The World Economic Forum estimates 395 million jobs could be created by 2030 through holistic investments in line with UN biodiversity guidelines. These investments will further support also public health.[66]

Biodiversity investments yield a five dimension return: create thriving natural environments; counter climate change; encourage social cohesion; create jobs; and improve health.

As the global community discusses how to ‚build back better‘ after COVID-19, policy making will re-focus on health outcomes as much as it will focus on avoiding negative impacts on biodiversity or climate change. The measurement and reduction of land-use footprints will be combined with investments in large areas of nature, devoid of human impact. Ecosystem restoration within settled areas is likely to increase. New green urban areas that allow fast and equal access to nature for physical and mental exercise, independent of socio-economic or ethnic status, will also contribute to the reduction of pollution, noise and heat island effects – and should not act as pathogen reservoirs. Furthermore, and not addressed here, research on new pharmaceuticals based on the benefits of genetic biodiversity will continue.

Insurers can enable and financially protect community green spaces against risks such as extreme weather or plant diseases and combat poor air quality. Improved physical and mental health outcomes relieve pressure on local social and health care structures and enhance community resilience.

Insurance can be an enabler of this new planning paradigm. The construction and operation of green spaces can be insured against a variety of risks. Health insurance can promote nature-based prevention activities that reduce health costs. In a holistic sustainability perspective, these potential investments into (re-)building green areas can have a positive social impact as well. In many cities only the more affluent people can afford to live nearer to green areas – and therefore face lower exposure eg to harmful pollutants. Where possible, the greening of urban or peri-urban areas must be fairly distributed throughout city areas, in order to minimise crowding-out effects on less affluent inhabitants because the value of privately owned properties will increase after a neighbourhood has become greener. Less affluent people who live in more affordable, but less green, urban areas often face a multiple penalty of higher exposure to health risks, and have less chances for a healthier lifestyle (eg while access to green areas is not nearby). Cheaper life and health insurance premiums are less obviously a social or societal benefit. Pushing town planning to smart inclusion of green areas makes sense from a life and health insurance perspective – as much as people should spend time in nature to prevent disease manifestation. Figure 4 shows how the integration of health, environmental policy targets and spatial planning principles might support expected health outcomes to the benefits of society.[67]

[64] B.W. Wheeler, R. Lovell, S.L. Higgins et al. *Beyond greenspace: an ecological study of population general health and indicators of natural environment type and quality.* Int J Health Geogr 14, 17 (2015). https://doi.org/10.1186/s12942-015-0009-5

[65] F. Ferrini, A. Fini, J. Mori, A. Gori 2020. *Role of Vegetation as a Mitigating Factor in the Urban Context.* Sustainability 2020. 12 (10), 4247 https://doi.org/10.3390/su12104247.

[66] A.Deutz, G.M. Heal et al. 2020. *Financing Nature: Closing the global biodiversity financing gap.* The Paulson Institute, The Nature Conservancy, Cornell Atkinson Center for Sustainability. World Economic Forum 2020. *The Future of Nature and Business.* Davos.

[67] E.L. Bird, J.O. Ige et al 2017

Figure 4: Health prevention and spatial policy

Planning Principles	Environmental and spatial policy target	Envisaged impact	Expected health outcomes
1 Reduce exposure to environmental hazards			
Improved air quality	→	Increased physical activity among older adults	→ Support to reduce risk of a) CVD b) type 2 diabetes, c) stroke, d) mental health problems, e) musculo-skeletal conditions and some cancers; improve mental wellbeing
Reduced air pollution	→	Reduced exposure to particulate matter and other gaseous pollutants	→ Support to reduce risk of COPD, supports healthy birth weight, reduction in myocardial infarction.
Reduced excessive noise	→	Reduced exposure to excessive noise	→ Support to improve mental health outcomes (older adults & children)
2 Access to and engagement with the natural environment			
Provision of access and engagement opportunities with the natural environment	→	Envisage physical activity and active travel	→ Support to reduce risk of a) CVD mortality, b) type 2 diabetes, c) cancer, d) obesity, e) stroke, f) mental health problems, g) musculoskeletal conditions and some cancers; supports to improve mental wellbeing
	→	Envisage social or physical participation among older adults Envisage physical activity among children	→ Support to increase mental wellbeing, cardiovascular health, supports to maintain a healthy weight, to improve bone health, self-confidence, development of new social skills, influences personal decisions which may lead to increased physical activity
	→	Envisage increase of first-time park users	
Aesthetic park improvements	→	Physical activity among all and especially among children and older adults	→ Support a) cardiovascular health, b) maintaining a healthy weight, c) improved bone health, d) improved self-confidence, e) develop new social skills, f) keeping musculose-keletal system healthy, g) supports to reduce cancer risk, obesity and type 2 diabetes risk. Supports to promote mental wellbeing
3 Adaptation to climate change and natural catastrophes			
Neighbourhood tree planting, green roofs etc.	→	Envisage reduction of urban heat island effects	→ Support diverse heat outcomes, eg reduced risk of heat wave induced excess death, improved sleep at night, etc.
Reduction of climate relevant emissions in all relevant sectors, carbon removal	→	Envisage to reduce (impact of) hot and cold periods and other extreme weather	→ Support to reduce excess summer/winter death and illness

Source: Slightly adapted from E.L. Bird, J.O. Ige, J. Burgess-Allen, J., A. Pinto, P. Pilkington 2017. Spatial planning for health: An evidence resource for planning and designing healthier places. Full technical report. Commissioned by Public Health England. June 2017. UWE Bristol, University of the West of England

Appendix

„The Big Six" Lifestyle factors

Lifestyle risk factor	Significance	Potential quantifiable parameters
Physical activity	Fundamental to establish baseline metabolism. Affects insulin sensitivity, improves heart health. Strength and mobility are key for healthy ageing.	Regularity of exercise, duration and intensity of physical activity
Sleep	Directly implicated in cognitive functioning, suboptimal conditions lead to chronic mental fatigue and are linked to hypertension, diabetes and CVD	Average sleep duration, extent and frequency of deviation from ideal, quality of sleep
Nutrition	Strong link with numerous biological pathways related to inflammation, fat storage, immune response, dyslipidaemia, insulin resistance, diabetes, obesity, autoimmune diseases and cancer	Ratio and quantity of primary food group consumption, consumption of processed or ultra- processed food, fasting, antioxidant, vitamin and mineral intake
Mental wellbeing	Intimately linked to physical health, resilience, recovery from illness and serious psychological diagnoses. Chronic stress linked to sympathetic dysfunction/ nervous system.	Mental stress, anxiety, unhappiness, coping mechanisms and a sense purpose
Substance use	Significant implications on both cognitive function and psychological impact. Numerous metabolites form toxins related to liver, cardiac and other organs	Frequency of use of illicit drugs, caffeine, alcohol, tobacco and medication
Harmful elements in the environment	Broad spectrum of pathological implications depending on the element. Examples: carcinogenic (radiation), respiratory illness (air pollution or passive smoking), vitamin D deficiency (lack of sun exposure).	Frequency of exposure to harmful elements, such as air pollutants including second-hand smoke, contaminants, pesticides and radiation

Source: Swiss Re 2020

Swiss Reinsurance Company Ltd
Mythenquai 50/60
P.O. Box
8022 Zurich
Switzerland

Telephone +41 43 285 2121
Fax +41 43 282 2999
www.swissre.com

Published by
Swiss Re Management Ltd
Swiss Re Institute
Mythenquai 50/60
P.O. Box
8022 Zurich
Switzerland

Telephone +41 43 285 2551

Author
Dr Oliver Schelske

The author would like to thank Simon Woodward, Christoph Nabholz, Prachi Patkee, John Turner, Corinne Kenny, Yommy Chiu, Bill Fellows, Peter Welten, Lukas Sundermann and Susan Leddy for comments and edits on earlier versions, and Jan Guddal for parts of the literature analysis.

Editor
Simon Woodward

Managing editor
Dr Christoph Nabholz
Swiss Re Institute – Chief Research Officer

The editorial deadline for this study was 30 September 2021.

The internet version may contain slightly updated information.

1507701_20_EN

09/21