
HUMAN HEALTH CO-BENEFITS OF GREEN STORMWATER INFRASTRUCTURE:

RESIDENTIAL GREEN SPACE OPPORTUNITIES IN SEATTLE & KING COUNTY

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April 2020

EXECUTIVE SUMMARY

There is an urgent need to address public health in all policies at the local government level. Increasing morbidity and mortality, expressed as decline in physical and mental health, increased chronic disease and other health concerns that span the human lifecycle, reduce quality of life and exact substantial public costs. While healthcare services are often the focus of public debate and policy, attention to the social determinants of health are increasingly recognized as a necessary upstream intervention to prevent disease and promote wellness.

King County, the City of Seattle and other local jurisdictions have launched stormwater management initiatives as part of their efforts to reduce combined sewer overflows (CSOs). Considering a Health in All Policies outlook, green infrastructure planning and design can incorporate environmental and landscape features that address locally identified human health concerns. This report includes an informal literature review of the research evidence demonstrating the potential for nature within communities to address high priority health needs and ease the burden of disease.

Providing landscape improvements and boosting residential greenness is a co-design for co-benefits opportunity as clean water, healthy habitat and CSO mitigation projects are designed and implemented. Projects such as green stormwater infrastructure, urban forest tree plantings, riparian restorations and

watershed enhancements can all include design elements that introduce nature within built communities or augment existing natural features with a focus on health. This report ends with some general guidelines:

- Enhance the Presence of Nature in Communities
- Promote Community Walkability and Physical Activity
- Enhance Connectivity of Existing Green Spaces
- Integrate Greening Initiatives with Transportation Planning and Systems
- Optimize Nature Views From Community Services Facilities
- Conserve and Expand the Urban Forest
- Promote Community Participation and Social Cohesion

ACKNOWLEDGEMENTS

This briefing was prepared with support from the joint King County Wastewater Treatment Division and Seattle Public Utilities Green Stormwater Infrastructure Program Management contract (under prime consultant MIG|SvR for SPU Contract #C12-004). Writing support was also provided by the USDA Forest Service, Pacific Northwest Research Station – Joint Venture Agreement with the University of Washington, 15-JV-11261985-063

Suggested citation: Wolf, K.L. 2020. Human Health Co-Benefits of Green Stormwater Infrastructure: Residential Green Space Opportunities In Seattle & King County. Seattle: University of Washington.

1. INTRODUCTION

King County¹ and City of Seattle² have separate consent decrees with the U.S. Environmental Protection Agency to address combined sewer overflow discharges into regional water bodies. They are but two of the many local jurisdictions around the United States that are working to better manage stormwater quantity and quality, while contending with historic infrastructure design practices and the uncertainties of climate change.

In addition, many local governments have identified the urgent need to address public health concerns and challenges. A Health in All Policies outlook encourages cross-agency and department leveraging of expertise and resources to address increasing morbidity and mortality, and increased chronic disease and other health concerns that span the human lifecycle and exact substantial public costs. While healthcare services are often the focus of public debate and policy, attention to the social determinants of health are increasingly recognized as a necessary upstream intervention to prevent disease and promote wellness.

This report starts with an overview of health and environmental policies and how they might be integrated. King County has identified major public health needs and challenges. The City of Seattle is

geographically located within the boundaries of King County and has similar human health challenges. These are similar to the public health trends of many local communities, and nature is one (of many, admittedly) social determinants that can prevent disease and promote wellness. An overview of current research about nearby nature and health is provided. The last section provides planning guidelines, translated from the evidence, to suggest how to integrate nature more intentionally with green infrastructure projects for human health.

2. HEALTH POLICY

The 2020 coronavirus epidemic laser focused public and healthcare attention on illness and disease. At this time epidemiologists and public leaders still do not know the full timeline and severity of the Covid-19 outbreak. In the back ground, and equally urgent are the ongoing illnesses and diseases that affect morbidity, mortality and quality of life in all communities. While we now are challenged by a highly contagious virus, many of the leading causes of illness and death in our state and nation have been, and will continue to be, chronic diseases – cardiovascular, respiratory, diabetes, etc. – that diminish health and quality of life for years, and can be expensive to diagnose and treat.

SOCIAL DETERMINANTS OF HEALTH

Current long term public health problems result not from any single causative agent, but rather from a number of interdependent influences. Social, physical, and economic environments and conditions, collectively referred to as the social determinants of health, have a far greater impact on how long and how well people live than medical care³. While clinical care is vitally important, only a small portion (15–20%) of overall health and longevity can be attributed to medical treatment⁴. Recent attention to social determinants is part of a policy shift from the diagnosis and treatment provided by healthcare services to upstream actions and investments in communities to help prevent disease and promote wellness. Reshaping people’s economic, physical, social, and service environments can help ensure opportunities for better health and support healthy behaviors.

HEALTH IN ALL POLICIES

Disciplines and public service sectors such as transportation, education, housing and economic development have traditionally been outside the domain of public health. To address local conditions that contribute to poor health and inequitable health disparities, public leaders must find ways to incorporate concern for and accountability to health outcomes into a wide range of decision making and public policies. More comprehensive attention to health can lead to projects that leverage nontraditional capital resources (such as infrastructure and roads construction) for indirect investments supporting long-term community health and well-being.

Health in All Policies (HAP) is a recognized approach that encourages state to local jurisdictions to holistically consider community and human health in all decision making for both public- and private-sector activities⁵. It establishes health and well-being as a priority across agencies and departments, from

local to state government levels. HAP success is dependent on collaborative teams of individuals from various disciplines combined with members of the community to develop and implement strategies for community-scale health improvements and to address the root causes of health disparities. Such efforts can and should be then integrated into the policies that shape and provide for governance of communities, such as urban planning comprehensive plans, transportation long range planning, and strategic plans for parks departments.

HEALTH IN ENVIRONMENTAL POLICY

The National Environmental Protection Act of 1969 (NEPA) addressed widespread concerns about decline in environmental conditions that affected health, particularly air and water quality. The landmark legislation established assessment and regulatory measures to promote environmental health and states eventually adopted similar strategies.

In 2013 both King County and the City of Seattle entered into consent decrees with the Environmental Protection Agency, Department of Justice, and the Washington State Department of Ecology to reduce sewer overflows and combined sewer overflows (CSOs) into regional watersheds and receiving water bodies. The resulting engineering efforts and innovations will directly protect public health and the environment by integrating stormwater control with plans for CSO control.

The consent decrees are legally binding agreements that focus programs, technical solutions and performance measurement on sewer system management and the direct health consequences of sewer overflow incidents. The decrees contain language about co-benefits opportunities. Considering the long term outlook of meeting decree requirements and the substantial capital investments to do so, meeting the decree requirements may also result in infrastructure and other facilities that enable secondary health benefits. This could include approaches that address additional social determinants of health.

CURRENT AGENCY PLANNING INITIATIVES

Clean Water Healthy Habitat is a new King County initiative intended to achieve and accelerate better water quality and habitat outcomes. Multiple departments are coordinating efforts and cooperating to develop King County-wide water quality and habitat goals by the end of 2020. The 30-year goals will be 'anchor points' for the County, and serve as the basis for outcome-based decision making and provide a means to evaluate progress. Internally, the goals will drive integration and collaboration, orient (and where necessary, re-orient) county work toward durable, equitable, and shared outcomes, improve communication among groups, and be used to set funding priorities and inform design criteria. Activities may include developing watershed management plans, restoring shoreline habitat, culvert repair, response to climate impacts, and pursuing collaborative water quality efforts (such as with tribes of the Salish Sea and Puget Sound region).

A new Water Quality Benefits Evaluation toolkit is also being developed to evaluate the cost-effectiveness of potential water quality investments for reducing pollutant loads, improving outcomes for the health of people interacting with water through swimming or eating fish and shellfish, and improving outcomes for Chinook and Southern Resident orca populations. This toolkit will be used to help decision-makers evaluate the water quality benefits of potential investments.

In addition, Shape Our Water is a multi-year effort of Seattle Public Utility (SPU) to integrate planning for its drainage and wastewater systems. The goal of this integrated planning effort is to identify the best investment strategies to achieve the greatest environmental and community benefits for Seattle at the lowest cost to the city’s customers. Racial equity and service equity lenses are being applied throughout the effort. Activities include robust technical and social analyses, innovative community visioning, risk area characterization and prioritization, community-engaged alternatives assessment and planning, and a focus on leveraging programmatic solutions and effective partnerships to meet Seattle’s infrastructure challenges. This integrated planning effort and its outcomes are a major step toward making SPU a community-centered utility.

3. KING COUNTY HEALTH CHALLENGES AND NEEDS

The King County Hospitals for a Healthier Community (HHC) collaborative is comprised of 11 hospital/health systems and Public Health - Seattle & King County. HHC has become an important collective impact group to address population health. The HHC works to identify community needs, assets, resources, and strategies towards assuring better health and health equity for all King County residents. HHC members are committed to working in pursuit of the “quadruple aim” of achieving health equity, optimizing health system performance by enhancing the patient experience of care, improving the health of populations, and reducing healthcare costs.

The HHC identified major health trends and corresponding challenges in a recent report - *King County Community Health Needs Assessment 2018/2019*⁶. Table 1 summarizes the trends and corresponding human health challenges from the report.

Table 1: King County Community Health Trends and Challenges

Health Trend	King County Assessment
Life Expectancy	Differences in life expectancy are linked to poverty and differences across locations and can be as great as 10 years
Leading Causes of Death	Cancer (lung, prostate, and breast most common) and heart disease are leading causes of death for older adults.
Chronic Illnesses	7% of adults have diabetes. 7% of children & 9% of adults have asthma.
Mental Health	30% of youth reported depressive feelings (sadness or hopelessness) that inhibited usual activities. 4% of adults experience serious psychological distress.
Pregnancy & Birth	30% of expectant mothers do not receive adequate prenatal care. 6.5% of infants are of low birth weight (less than 5.5lbs)
Physical Activity	22% of school age youth meet federal standards for <i>physical activity</i> , about the same rate as adults.
Weight	9% of school age youth are obese, while 22% of adults are obese (BMI>30).
Violence & Injury Prevention	Suicide deaths are 4.5 times the rate of homicides, and is the leading cause of death for young people.

ENVIRONMENT AND HEALTH – RISK VERSUS REWARD

Some of the health challenges noted in the HHC report may be due to lack of access to healthcare services. Social determinants of health, the upstream influences on clinical medical conditions, mediate many of the health challenges. The needs assessment report calls out Community Identified Priorities to improve health and assets. A section on Equity and Social Determinants of Health called out Worse Environmental Conditions, focusing on harmful environmental exposures. While this has been the traditional focus of environmental regulatory agencies and public health officials, the focus on risk fails to acknowledge the array of health benefits that are provided by quality, secure and accessible green spaces within communities. Prevention and mitigation of the public health conditions (as described for King County) have been scientifically correlated to the presence of nearby green space in urban environments.

The next section presents the extensive evidence about the role of nearby nature in communities and positive health outcomes. It suggests why guidelines for nearby nature provision should be a health in all policies approach and become an element of all local government initiatives that address environmental health, habitat and public health. This outlook is reinforced by a recent publication of the Willamette Partnership (in partnership with the City of Seattle and other local governments), the Green Infrastructure and Health guide⁷².



Urban nearby nature supports environmental services, human health and social cohesion co-benefits. *image credit: Kathleen Wolf*

4. COMMUNITY NATURE AND HUMAN HEALTH

How might nearby nature be integrated with other initiatives to address concerning health trends? What is the evidence that points to the role of nature within communities in disease prevention and wellness protection?

EVIDENCE OF NATURE AND SALUTOGENIC EFFECTS

Research about the associations between nature within communities and human health response has been underway for nearly 40 years. In recent years a surge of studies has expanded the evidence about nature experience and salutogenic effects, and revealed the full range of beneficial responses. A University of Washington web site – Green Cities, Good Health – is a research review oriented to

professional and manager audiences. The science summaries are derived from thousands of articles about nature and health in cities, published from studies around the world.

The presence of nature in communities – be it public parks or gardens, streetscapes, the urban forest and even private landscapes – can be considered a social determinant of health. These nearby nature elements are often planned and managed by parks or natural resources agencies to provide aesthetic amenities and recreation. Their impacts, highlighted in this section, merit their inclusion more broadly in health in all policies initiatives⁷.

CONDITIONS AND ASSUMPTIONS OF STUDIES SELECTION

This informal literature review presents the studies that are relevant to policies, initiatives and programs in the Seattle metropolitan area. It provides information to support inclusion of community greenspace as a health in all policies element for response to health needs assessments and clean water and healthy habitat initiatives (in King County and beyond). Table 2 contains references to studies that directly relate to identified health needs in King County; full citations are provided as endnotes. The conditions of article selection and screening included:

- Studies that directly explored the health needs listed in Table 1 for King County. While the needs were identified for one jurisdiction, public health data shows that such health trends are similar for many municipal and county area in the Puget Sound region.
- Nature exposure was expressed as degree of vegetation presence or cover within or near residential areas at the neighborhood or parcel scale. Proximity to parks was secondary, as this report is exploring the opportunities for greening as a supplement to parks systems⁸.
- Scientific methods range from epidemiological, cross sectional studies covering geographies of regions, nations or across nations to studies that are natural experiments or random controlled trials in laboratory or more local situations.
- Researchers controlled for socio-economic status when studying nature effects, as there are other health advantages in affluent neighbourhoods (e.g. better nutrition and health care access).

STRENGTH OF EVIDENCE SUMMARY

As for any field of science there are caveats – and these are similar across formal and informal reviews of the nascent science of nature and health. Although the number of studies on greenness and health benefit is growing, findings are still inconsistent for some outcomes; the strength of evidence for greenness and human health should be improved by additional research. Although many findings are correlational, the confluence of results from experimental and correlational studies is encouraging. More large-scale prospective studies with multiple health endpoints would add clarity on the relationship between greenness and health. Benefits may vary by socioeconomic status, preferences, residential location, occupation, personality traits, culture, gender, and age. Effects may also differ according to the type of interaction with nature, such as forest immersion versus views from windows, and the form of sensory input (e.g., visual, olfactory, auditory, or tactile). In addition, little is known about the duration of these effects, although some studies have found that some benefits last for substantial periods of time. Notably, most of the research is situated in urban contexts within the temperate Global North⁹, similar to the bioclimatic conditions of the Puget Sound region.

Table 2: Literature Review – Residential Greenness and Health Responses that Align With King County Health Assessment

Health Trend	Research Evidence
Life Expectancy	<p>Two reviews of epidemiology studies^{10 11} found generally consistent evidence that increased greenness is associated with lower mortality based on analysis across large populations and geographies. Mechanisms include the role of green spaces and vegetation on multiple upstream causes of death, such as buffering exposure to harmful pollutants, increasing physical activity, providing a setting for social engagement, or through direct effects on mental health. These effects generally are consistent across communities of all socioeconomic conditions, including those less resourced. For example, when tracking 5 year mortality for elders, one study found that residential areas with walkable green spaces positively influenced longevity independent of participants' age, sex, marital status, baseline functional status, and socioeconomic status¹². A large cohort study (1.3 million adult Canadians across 30 cities) showed that higher levels of greenness were associated with lower rates of all-cause, cardiovascular, and respiratory mortality¹³. A study of women found that having the most greenness within a 250 m area around their homes had a 12% lower rate of all-cause nonaccidental mortality than those having the least green, even when adjusting for mortality risk factors¹⁴. More details about these topics follow.</p>
Leading Cause of Death - cancer	<p>At this time cancer is one of the least studied outcomes of nature experience. There are known pathways for the disease; for instance, carrying excess body weight is linked to at least 13 cancer types and to about 7% of all U.S. cancer deaths (see Weight below). Concerning residential greenness, male residents of Montreal Canada living in greener areas (of up to 1000 m), either recently or about a decade earlier, had lower risks of prostate cancer, independent of socio-demographic and lifestyle factors¹⁵. A national U.S. study found that women living within the highest quantile of community greenness had a lower rate of all-cause mortality, with findings strongest for respiratory and cancer mortality, and mediated by physical activity, aerial particulates, social engagement and depression¹⁴. An intriguing finding in Japan was that visits to forest parks enhanced human natural killer (NK) activity, increased anti-cancer proteins and reduced the level of stress hormones in both men and women with effects lasting for more than 30 days; the authors concluded that forest visits may have a preventive effect on cancer generation and progression¹⁶. Considering cancer outcomes (and perhaps all topics in this table) the relationship to green space will likely vary by geographical context. For instance, a study of skin cancer in Australia found that people with >80% green space showed a 9% higher risk of having skin cancer than those having 0-20%¹⁷. Also, cancer survivors face challenges when reintegrating their lives, and a study found that nature experiences counteracted attentional fatigue, improving cognitive processing capacity of breast cancer patients¹⁸.</p>

Health Trend	Research Evidence
Leading Cause of Death - heart disease	<p>A study using Swiss national health data for millions of people examined mortality based on multiple causes and found that higher levels of residential greenness were associated with lower risk of cardiovascular mortality¹⁹. Other studies of more limited geography showed similar results. Analytic models of sudden cardiac death found that, at the census tract scale, increases in greenway density within 1 km/km² were associated with risk decrease of 18%, and decline of 10% with 10% increase in forest area²⁰. Following rapid tree loss (due to insect damage) across 15 states a natural experiment study found an increase in mortality related to cardiovascular and lower-respiratory-tract illness²¹. Similarly, women living in area with insect caused tree loss increased risk of cardiovascular disease²². In a study of hundreds of patients recruited from a preventive cardiology clinic, biomarkers of cardiovascular injury and risk showed lower values for people having more greenness within 250 m of their homes²³. Using data from the Ontario Health Study investigators found that people who live in neighborhoods with a higher density of trees on their streets reported significantly higher health perception and significantly less cardio-metabolic conditions. Expressing the findings in economic terms, they found that having 11 more trees in a city block, on average, decreased cardio-metabolic conditions in ways comparable to an increase in annual personal income of \$20,000 and moving to a neighborhood with \$20,000 higher median income (2014 values)²⁴.</p>
Chronic Illness - diabetes	<p>In the Australian 45 And Up study the rate of type 2 diabetes was 9.1% for adults in residential neighborhoods with 0-20% green space, but dropped to approximately 8% for participants with over 40% green space²⁵. A study involving 33 urban communities in China found that higher residential greenness was associated with a lower prevalence of diabetes, though linked pathways may be lower levels of air pollution and body mass index²⁶. Another study confirmed the relationship between better residential walkability and reduced diabetes²⁷. A study of adults and leisure-time physical activity reported that at least 19% of incident diabetes cases could be avoided if the inactive participants had engaged in WHO recommendation levels of physical activity²⁸. Chronic disease morbidity often involves multiple conditions. For adults with type 2 diabetes, a study found lower risk of depression associated with more physical activity facilities, cultural services and a greater level of greenness in one's neighborhood.</p>

Health Trend	Research Evidence
Chronic Illness - asthma	<p>Respiratory sensitivity, allergy and asthma are often complex and inter-related health conditions. Aerial pollens, particularly from certain tree species (such as cedar, cypress), can be associated with allergic rhinitis, which can exacerbate asthma. The prevalence and allergy response to pollen is dependent on type of vegetation, tree canopy cover²⁹ and density, tree sex (meaning a preponderance of male trees), building configurations, and weather conditions³⁰. A time lag study in London found a 4-5 day gap between high, continuous daily counts of grass pollen and adult hospital admissions for asthma³¹. Air pollution and airborne fine particulates are associated with respiratory irritation and other health consequences: cardiovascular disease³², migraine headaches³³, decreased lung function, premature mortality, low birthweight in infants, diabetes, cancer and reduced life expectancy³⁴. Trees may reduce aerial particulates through deposition on leaf surfaces³⁵, however trees in urban street canyons can also concentrate local air pollution by reducing air circulation³⁶. Green screens that include trees and shrubs can physically block the movement of particulates from sources, such as high speed roads³⁷. In addition, species with more complex stem structure and smaller leaves had greater capture efficiency³⁸.</p>
Mental Health - psychological distress	<p>A recent review article characterized the wealth of studies that demonstrate how nature experience is associated with psychological well-being⁹. The evidence links nature experience with increased positive mood; happiness and subjective well-being; improved sense of meaning and purpose in life; improved ability to manage life tasks; and decreases in mental distress. Direct investigations include a study of more than 4,000 adults that found fewer people reporting poor health when there was more residential greenness within 100 m of homes, plus increased neighborhood satisfaction and social capital³⁹. Attention restoration theory addresses the increased cognitive depletion associated with high-demand lifestyles, finding that nature (which is filled with intriguing stimuli), modestly grabs attention in a bottom-up fashion, restoring top-down directed-attention abilities⁴⁰. This improves psychological executive functioning, meaning the processes that involve mental control and self-regulation, and enable a person to manage personal resources towards goals⁴¹. Biodiversity may play a role as a study of neighborhood vegetation found a dose response; mental health issues declined when percent cover reached thresholds: less stress at more than 20%, less anxiety at 30% or more⁴². In a study focusing on children, greater amounts of greenness surrounding the home, commuting route and school were aligned with better working memory and reduced inattentiveness over a 12 month monitoring period, results which were partly mediated by reduction in air pollution exposure⁴³.</p>

Health Trend	Research Evidence
Mental Health - depressive feelings	<p>A recent review article characterized the numerous studies show associations between nature experience and reductions in risk factors and incidence of some types of mental illness, including depression⁹. Acute and chronic stress are precursors to several mental illnesses, including depressive symptoms. One of many studies about nature experience and reduced stress a time found that a stress biomarker (salivary cortisol) was most effectively reduced after a 20-30 nature dose in the context of normal daily life⁴⁴. Other studies have directly indicated that greater access to green space is associated with less depression in adults⁴⁵, that improvements in perceived greenery are related to a decrease in adults' depressive symptoms⁴⁶, and that increased levels of residential greenness provided a protective effect on depression, with greater benefit for women, people younger than 60 years, and people in low socioeconomic status neighborhoods⁴⁷. In an experimental study people diagnosed with major depression took 50 minute in a more green residential area then later in a more built neighborhood, and more nature was associated with increases in memory span and improved mood⁴⁸. What is a pathway to improved depression? A trait of depression is persistent negative self-referential thoughts, termed 'rumination'. Recent studies show that walks in nature of an 1-1.5 hours decrease the intensity of rumination⁴⁹.</p>
Pregnancy & Birth (infant birth weight)	<p>Multiple studies in cities indicate that maternal exposure to greenness affects birth outcomes, particularly measures of small for gestational age and birth weight, possibly via pathways of increasing physical activity, improving mental health, and buffering detrimental effects of air pollution, noise, and extreme heat exposures⁵⁰. Though controlling for spatial and demographic traits, a study in Vancouver B.C. found that increased greenness was associated with higher term birth weight and decreases in the likelihood of small for gestational age, very preterm (< 30 weeks), and moderately preterm (30-36 weeks) births⁵¹. Another controlled comparison in Portland OR found that a 10% increase in tree-canopy cover within 50 m of a house reduced the number of small for gestational age births by 1.42 per 1000 infants⁵². There may be long term consequences for a child as a study found that a 22% increase in the proportion of green space within 5000 m around the maternal residence was associated with on average a 3.62% longer telomere length in umbilical cord blood cells⁵³, and short telomere lengths are linked to impaired fetal growth and brain development in children. Less research has been done on parent health, yet one study found that pregnant women who resided in the neighborhoods having higher levels of greenness were 18–23% less likely to report depression symptoms⁵⁴.</p>

Health Trend	Research Evidence
Physical Activity (federal standards)	<p>Higher levels of greenness in one's community, or closer proximity to nature show mixed associations with increased physical activity¹¹, particularly in cross-sectional studies. Some increases have been found for leisure time activity, as well as active travel (walking, cycling, or public transport)⁵⁵. Studies typically test the incidence of physical activity and parks proximity, though some studies address general neighborhood greenness. Substantial increases in the green quotient within 500 m of people's homes were linked in one large study with a 9.3% increase in the likelihood of using active travel (walking, cycling, or public transport) for non-work trips, and a 3.9% increase for walking for physical activity more than 30 min per day⁵⁶. In a study focusing on children it was found that for each additional 5% increase in tree cover of the home neighborhood there was a corresponding 5% increase in the free-time physical activity outside of school hours for 11 to 13-year-old children⁵⁷. A sample of women living across the U.S. showed that those who lived in areas with the greatest amount of community greenness (up to 500 m) were 17% more likely to engage in higher energy expenditure hours per week for all physical activity, including recreational activity⁵⁸. Finally, across multiple studies it has been found that exercising in natural environments was associated with greater feelings of revitalization and positive engagement, decreases in tension, confusion, anger, and depression, and increased energy when compared to activity indoors. Participants reported greater enjoyment and satisfaction with outdoor activity and declared a greater intent to repeat the activity at a later date⁵⁹.</p>
Weight (BMI & obesity)	<p>The associations between access to parks and BMI (body mass index) is inconclusive, though studies assessing general residential greenness show associations with more healthy body weight. A national level study found that increased residential greenness was associated with adult lower adiposity (one's comprehensive weight state), including lower BMI and whole body fat, smaller waist circumference and reduced relative risk of obesity⁶⁰. A Swedish study of more than 5,000 adults found that higher long-term exposure to residential greenness (of up to 500 m) was associated with fewer increases in waist circumference and lower risk of central adiposity in women, but not in men⁶⁰. A sample of women living across the U.S. showed that those who lived in areas with the greatest amount of community greenness (up to 500 m) had a reduced risk of obesity relative to those having the least greening, and were 17% more likely to be physically active (which was a 32% mediating factor)⁶². Concerning younger people, a two year study of BMI of children and youth (aged 3-16 years) found that more residential greenness within 1 km was significantly associated with lower BMI, and were not influenced by residential density characteristics⁶¹. In New York, children in lower income families had a reduced risk of obesity if they lived in an area with a higher density of trees⁶². Less affluent families might be more restricted to their immediate surrounding and thus benefit more from greenspace availability.</p>

Health Trend	Research Evidence
Violence & Injury Prevention	<p>In a review of 45 studies⁶³, the majority of papers linked the presence of community green space with reductions in violent personal crime, including gun violence. Nature based mechanisms include social interaction, physical activity, community perceptions, biophilic stress reduction, climate modulation and social territorial definition of spaces (including routine maintenance and upkeep). Nature encounters appear to influence crime related behavior. For example a time series study found that increased exposure to neighborhood green space (within 1,000 m of home) was associated with reduced aggressive behaviors in adolescents, and that increased vegetation (typical of urban environments was equivalent to approximately 2 to 2.5 years of developmental maturity⁶⁴. Another study using pre/post measurements of tree loss within census blocks due to an insect pest. Insect infestation (followed by tree death and removal) was significantly and positively associated with relative increases in 7 of 11 crime categories⁶⁵. An intriguing study traced the before-event activity of firearm injury patients and found that, compared to time controls, time spent under tree cover reduced the odds of gunshot assault, especially in low income areas⁶⁶. In one of the few direct investigations of green stormwater infrastructure, quasi-experimental study of installations did not find any significant effects on violent crimes but did find reduced narcotics possession arrests around greened sites compared to control locations⁶⁷.</p>

5. EQUITY OPPORTUNITY

The King County Health Assessment report identified pervasive needs and revealed that some residents experience stark differences in health that are conditioned on place, race, and income. In many ways, “place” is often a proxy for opportunities to access social determinants of health, such as work, education, healthcare, food, and recreation. The report evaluated regional differences in health indicators and identified neighborhoods with the greatest opportunities for improving health. Generally, South King County is home to some of the most racially and ethnically diverse communities, and these places display disparities in multiple health and social indicators.

Other natural resources analytics have identified disparities in the distribution of parks, trees and greenspace across the Seattle metropolitan region. While there is no evidence of a causal relationship, there is overlap in the spatial representations of deficient human health and greenspace absence.

Improving the quantity and quality of green space is rarely called out in human health improvements initiatives. Yet nearby nature may actually reduce socioeconomic health inequalities. One study of people with low income and high levels of residential greenery had similar mortality rates to people having higher socio-economic status. However, when low income was associated with little surrounding green space, higher mortality rates were found⁶⁸. For the birth studies in Table 2 outcomes are often modified by socioeconomic status (SES), with stronger findings among study participants of low SES¹¹.

Why might improved health be aligned with low SES communities? Why might nature-based positive effects be amplified in lower SES communities? Poverty is related to poorer health across the human life cycle, from children to elders. Living in more challenging situations that include crowding, less dependable transportation, reduced air quality, and increased threat of crime contributes to chronic mental fatigue. Nature’s healing and restorative benefits can help people regain mental capacity and cope, reducing anxiety and other precursors of chronic disease, as contact with nature within one’s neighborhood has been linked to residents’ lower perceived stress and improved physiological stress recovery⁶⁹.

6. NATURE FOR HEALTH ACTION GUIDELINES

There is an urgent need to address public health in all policies at the local government level. Increasing morbidity and mortality, expressed as decline in physical and mental health, increased chronic disease and other health concerns that span the human lifecycle, reduce quality of life and exact substantial public costs⁷⁰. While healthcare services are often the focus of public debate and policy, attention to the social determinants of health are increasingly recognized as a necessary upstream intervention to prevent disease and promote wellness.

Earlier, Table 1 presented a set of high priority health needs in King County, and Table 2 outlined research evidence demonstrating the potential for nature within neighborhoods to ease the burden of disease.

Providing landscape improvements and boosting residential greenness is a co-design for co-benefits opportunity as clean water, healthy habitat, reduced CSO mitigation and stormwater retrofit projects are designed and implemented. Projects such

as green stormwater infrastructure (GSI) technologies, urban forest tree plantings, riparian restorations and watershed enhancements can all include design elements that introduce nature within built communities or augment existing natural features with a focus on health. GSI technologies include permeable pavements, rain gardens, planted bioretention cells, green roofs and vegetated biofiltration swales. This report focuses on the vegetated and landscape GSI technologies that may provide health benefit.



Green stormwater infrastructure includes a range of technologies, and can add vegetation and landscape amenities to residential areas. *image credit: MIG | SvR*

RAPID HEALTH IMPACT ASSESSMENT

The American Public Health Association describes Health Impact Assessment (HIA) as a systematic process to determine the potential effects of a proposed policy, plan, program, or project on the health of a population and the distribution of those effects within the population. Five principles are central to the assessment definition and process: democracy, equity, ethical use of evidence, sustainable development, and a comprehensive view of health.

While more complete analytics are expected for a formal HIA, agencies and communities may conduct a Rapid HIA (R-HIA) to quickly assess conditions and opportunities, and to provide goals and guidance for a more thorough HIA. An R-HIA may entail a desktop screening or scoping exercise, such as access of GIS maps or online public health data. Another version seeks to engage stakeholders and professionals more directly. An interactive workshop — taking half a day or a day — brings together representatives of collaborating organizations to identify and assess health impacts, understand key concerns and interest groups, and to initiate the subsequent write up and follow-up actions from the workshop results.

PRACTICAL ACTIONS

Here are practical actions and recommendations that can boost nature encounters and experiences for residents. These actions can be interpreted as benchmarks for evaluating nature presence for a Rapid Health Impact Assessment, or provide a framework for health benefits co-design as an environmental project is being planned.

Enhance the Presence of Nature in Communities – This very general recommendation acknowledges the wide disparities of the presence of nature across various communities – within and across cities. Where there is some latitude in the choice of where to locate green infrastructure, effort should be made to boost the extent and amount of nature in communities that are of higher density or where nature amenities are relatively sparse. GSI installations are not a substitute for inadequate presence of parks and trees but can nonetheless be envisioned as micro-parks or gardens to supplement broader green space infill or development initiatives. A general rule of thumb? A recent review found that enhancing green space gaps up to 2000 m from residences can encourage better physical health⁷¹. GIS could be used to conduct a spatial gap analysis using various buffer distances.

Promote Community Walkability and Physical Activity - Provide for and enhance green spaces that enable comfortable and secure walking in and about one's community. The Trust for Public Land encourages a 10 minute walk goal, in that every resident be able to access a park within a 10 minute walk of their home. But this assumes that one can continue the activity after arriving at the green space. Research shows that walks as brief as 20-50 minutes, even just within green streetscapes, provides stress reduction and improved mood. And having appealing, nearby walking spaces may help residents to commit to recommended guidelines for weekly physical activity – 60 minutes a day for children and a total of 150 minutes per week for adults. Features can include improved streetscapes, trails or paths, or walking loops.

Enhance Connectivity of Existing Green Spaces – Communities have different quantities of parks, gardens or nature reserves. Whether more or less in any particular place, such public amenities have rarely been planned across a jurisdiction in a comprehensive way, such as in the ways that transportation or utilities are planned. Thus public nature amenities and green spaces may be located in an ad hoc way, of unequal presence or density. New or enhanced installations of GSI and habitat restoration can be designed to promote visual and physical connectivity across the open space assets of a community. While once regarded as mere aesthetics, opportunities for connected, sustained contact with nature promotes wellness.

Integrate Greening Initiatives with Transportation Planning and Systems – Road rights-of-way and surface parking areas together comprise major land use and cover area in many cities. Green infrastructure installations are often placed in both public and private transportation corridors and parking areas, as impervious surface runoff contains substantial pollutant loads. Co-design of roadside and parking lot bioswales, rain gardens and other green infrastructure elements can introduce health promoting green in areas having high visibility and resident encounter. Transit networks include bus, rail and streetcar. Transit nodes and centers can include landscape features that foster stress recovery and other benefits as people experience nature while waiting for transit arrivals.

Optimize Nature Views From Community Services Facilities – Civic service facilities may include libraries, recreation centers, health and therapy clinics, community and neighborhood meeting spaces, and administrative facilities, such as city halls. Each of these buildings may have associated space for landscape. Rather than regarding such landscapes as simply ornamental they can serve restorative and wellness purposes. Designing landscapes for immediate views from within the building offers restorative opportunities as people engage in meetings, wait for service providers, take breaks, and arrive/depart from the building. These landscapes can also serve as community models. Many green infrastructure installations in civic settings include interpretive signage; the presented information could include how and why landscape elements contribute to personal and household health.

Conserve and Expand the Urban Forest – There are many natural structures and elements that can be included in design for nature and health outcomes. Across the years of environmental psychology research trees are highly preferred landscape elements in cities, and a literature review (in review for publication) indicates that visual and immersive experiences of trees provide diverse human health benefits. In addition, trees provide co-benefits associated with improved air quality, stormwater management, reduced urban heat island effects and climate effects adaptation. Efforts should be made to conserve and preserve large trees when possible, as the benefits quotient is many times greater for large trees compared to smaller ones.

Promote Community Participation and Social Cohesion – King County, the City of Seattle and many other local jurisdictions have enacted policies that aim at health and environmental equity. The policy documents and equity advocacy organizations highlight the importance of community engagement for environmental practices and landscape interventions that are culturally and historically sensitive, and leverage the local strengths and resources of communities. The process of understanding green infrastructure, contributing to its planning and implementation, and perhaps being involved in stewardship can promote social cohesion across a community. Community connections can lead to greater social capital and efficacy, mediators of better health. Additional specific guidelines to promote nature as a social determinant of health and processes of engagement for equity in nature design can be found in the publication, *Green Infrastructure & Health Guide*, a [downloadable](#) report from the Willamette Partnership.

More Ideas and Information - Additional specific guidelines for design at the parcel and site scale can be found in the publication, *Cascading Benefits: Designing Green Stormwater Infrastructure for Human Wellness*, a [downloadable](#) report from The Nature Conservancy.

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