A healthier future with a little help from our nature

Case studies on the contribution of green infrastructure to people's health

CEEweb for Biodiversity

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Green infrastructure, ecosystem services and human health

Review of an overarching study of literature by Christopher Coutts and Micah Hahn, published in the International Journal of Environmental Research and Public Health, 2015, no. 12.

Introduction

Where other studies have tended to focus on ecosystem services (the benefits which ecosystems provide to human society) individually, this overarching study takes the whole picture into account. Ecosystem services do not exist automatically, but are provided by healthy, functioning ecosystems. These form a 'green infrastructure' (GI) serving the population in their area.

A variety of topics are discussed, a selection of which are presented here. They range from pharmaceuticals, air quality, climate change and urban heat, to physical and mental health, to community spirit. In each and every topic, a strong case is made for the ecosystem services GI provides, particularly trees and green spaces, and their potential to alleviate or solve problems associated with that topic.

Pharmaceuticals

Plants and other organisms within GI harbour rich reserves of compounds that can be used in pharmaceuticals:

- At least half of US prescribed drugs are either directly taken from natural sources or derived from them. [1]
- 30% of drugs sold worldwide contain compounds derived from plant material. [2]

As well as currently used pharmaceuticals, the vast number of plant species which have not yet been studied could hold even more. The greater the diversity of plant species, the more potential discoveries there are to be made. Therefore, preserving GI means preserving the natural inventory which provides us with pharmaceuticals.

Air quality

Poor air quality, responsible for respiratory and cardiovascular diseases, is a common problem in urban settings. Since some plant species, especially trees, are capable of removing gaseous and solid pollutants from the air [3], GI has an important role to play in improving air quality – although emissions must also be reduced.

- One study found that in 2010, the number of acute respiratory problems and deaths that the US avoided thanks to trees and forests' uptake of pollutants saved their economy $6.8 billion. [4]

Climate Change Mitigation

Of the 14 hottest years on record since 1850, 13 have been in the twenty-first century. Although it is vital to cut emissions in order to prevent a catastrophic rise in temperature, it also makes sense to recapture some of the carbon that has been released.

- In 2005, the US forest sector sequestered (removed from the atmosphere and stored) enough carbon to offset an estimated 10% of CO_2 emissions that year. [5]
- Larger, more mature trees store more carbon than young ones, but young trees capture carbon at a faster rate. It therefore makes sense to *both* preserve old forests, *and* plant new ones.
- Burning wood from sustainable forests for fuel is far more carbon-neutral than burning fossil fuels. If managed sustainably, forests may be able to provide both fuel and building materials while also sequestering carbon.

Urban Heat

The "urban heat island" effect is a well-studied phenomenon. As heat in cities rises, so too will the risk of heat-related ailments…

- High temperatures can cause discomfort in the form of heat cramps, heat edema (swelling) and fainting. It can also cause more serious ailments such as heat exhaustion and heatstroke, which sometimes lead to organ damage and even death. [6]
- Any city with a population over a million can have an average temperature 1-3^{o}C higher than that of the surrounding region [7], or – according to another study – as high as 7^{o}C. [8]

…but planting greenery, especially trees, can counteract this effect. The benefits increase the more is planted, but even a single tree can have an impact:

- In a high-density urban environment, if just 10% of the area is covered by Green space with trees, this can reduce local surface temperature (temperature on or near the ground/buildings) by 1.4^{o}C on average. [9]
- Just one tree can have a sun protection factor of 6 to 10 (UV radiation in the tree's shade is just one sixth or one tenth of UV radiation in full sunlight). [10]

Physical Health

GI in the form of parks and other green spaces is a huge asset to a community's health, but only if it is accessible to all. This is another strong argument for increasing the percentage of green space within cities.

- It has been shown that the greenness of neighbourhoods correlates with lower instances of child obesity. [11] A healthy childhood leads to a healthy adulthood.

Mental Health

Humans have an inbuilt preference for natural environments, and spending time in or around them has been shown to improve mental health in a variety of ways:

- As long ago as 1984, research suggested that hospital patients with a view of trees from their window recovered more quickly and needed fewer painkillers than those with a view of brick walls. [12]
- Urban environments are very information-rich, which can lead to attention fatigue (decreased ability to concentrate). Spending time in natural environments allows the brain to recover from this. [13] Therefore, increased access to green spaces in cities could improve the performance of employees at work, and also mitigate some of the symptoms of ADHD. [14]

Community Spirit

Providing green spaces in cities promotes social bonding, which reduces loneliness and leads to better mental health. Social relationships have been shown to be as important to human health as more obvious factors (smoking, obesity, high blood pressure). [15]

- Greener areas attract larger groups with a wider age range [16], and 83% more social activity takes place in them as opposed to barren spaces (for every age and gender). [17]
- More greenspace in a person's immediate neighbourhood correlates with a better perception of their own health and lower feelings of loneliness, especially for those with low mobility. [18]

Conclusion

While each of the issues examined – medicine, air quality, mental health etc. - may seem to call for very different measure if taken individually, an increase in green infrastructure, particularly forest, trees and green spaces, can have a beneficial impact on all of them simultaneously. Trees

and plants maintain themselves if allowed to do so, making this solution not only holistic, but low-cost too.

Recommendations

Where possible, policy should support:

- The preservation of existing forests
- The planting of new forests
- The sustainable management of existing forests which provide fuel and timber, so that they can continue to be both carbon sinks and direct economic assets
- The creation and maintenance of public green spaces in cities, including parks, trees and other features such as green walls

In the words of the authors of this paper:
"underselling the importance of GI to health puts both GI and health at risk"

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Blue-green infrastructure in Łódź

Synopsis

Blue-green infrastructure, a combination of green spaces and healthy water bodies, is respected by a variety of stakeholders as a tool to alleviate exercise and allergy-related health concerns and improve general quality of life. A demonstration in the Polish city of Łódź led stakeholders to take the initiative in reviving their own, historically degraded blue-green infrastructure.

Background

Industrialisation in Łódź during the 19th century heavily degraded aquatic ecosystems. Rivers were channelised and integrated into the sewage system. SWITCH, an EU partnership created to research water management in cities, brought demonstration projects to Łódź. These projects inspired local developers, architects, NGOs, scientists and others and in 2006, a Learning Alliance was established in Łódź. This platform developed an overarching concept: the Blue-Green Network, made up of existing areas as well as ones that could potentially be restored (rivers and their valleys, agricultural areas, parks, urban wastelands). It was officially adopted in 2012.

Problems

- Channelized rivers and impermeable surfaces such as tarmac reduced the land's ability to absorb rainwater. This meant less moisture was retained in the soil, leading to lower air humidity, which contributed to the 'heat island effect' (cities are on average several degrees warmer than their surroundings) [1]
- Among Poland's large cities, Łódź had the highest rate of ailments which could be prevented by regular exercise: cardiovascular diseases, psychic disturbances from excessive stress, tumours
- Like in many cities, degraded areas were aesthetically and psychologically unpleasant for their inhabitants
- The city suffered from poor air quality

Solutions

In 2006, a Learning Alliance was established in Łódź as a platform for stakeholders. The overarching concept developed was that of a Blue-Green Network, made up of existing areas as well as ones that could potentially be restored (rivers and their valleys, agricultural areas,

parks, urban wastelands). The following actions were planned, and pilot projects were implemented:

- Rehabilitating the Sokołówka river and the surrounding natural landscape. Evaporation and transpiration from plants and water bodies help lower air temperatures and combat the urban heat island effect. Plants also trap pollution particles [2], improving air quality.
- Developing the Sokołówka river park. Blue-green areas are aesthetically attractive, giving them potential for recreation. Outdoor recreational spaces have been shown to encourage physical activity, with resulting health benefits. [3] Studies also show that access to natural spaces during everyday life is beneficial for mental health [4], which is particularly important to those without the means to travel out of the city regularly.

Conclusion

The health benefits of activities planned and undertaken have yet to be quantified, but stakeholder cooperation in Łódź shows strong consensus on their value. Pilot projects have been a success, and the plans for rehabilitation of the Sokołówka river and development of a park have been approved by the city council. Nonetheless, lack of funding has delayed implementation, showing the crucial role the EU plays in funding such projects.

Recommendations

Blue-green infrastructure has strong support across a range of stakeholders and is a worthy candidate for EU funding.

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Green roof on the Copernicus Science Centre, Poland

Synopsis

Urban development in Warsaw has resulted in unhealthily high temperatures and noise levels. Green roofs can mitigate this effect.

Background

Warsaw is Poland's largest city by population, and like all large cities is vulnerable to noise pollution and the urban heat island effect. Urbanising the banks of the river Vistula has changed the microclimate and physical environment, rendering it unsuitable for the plant species which used to grow there. The Copernicus Science Centre, built by the winners of an architecture competition in 2005, features ecological innovations including a 'green roof'.

Problems

Heat: in August 2018 Warsaw broke its previous temperature record, reaching 36.6ºC. Daytime temperatures hovered around 32ºC for 11 days straight, far longer than normal. Climate change is set to bring more summers this hot or hotter.

Noise: in 2015 an EEA report clearly stated that residents of Warsaw were exposed to excessive noise levels.

Solution

Although it stands on the bank of the river, the microclimate on the roof of the Science Centre is unsuitable for riverside plants, being exposed to intense sunlight and with no windshield. Instead, 'xeromorphic' plants – ones adapted to living in places where water is scarce – have been used to cover the roof.

Roofs made of traditional building materials can reach 80ºC in summer sunlight, which heats up the inside of the building too. By contrast, the biological covering on the Science Centre remains at the ambient temperature (for example, 32ºC).

The layer of plants reduces ambient noise by about 8 decibels. This may sound like a small amount, but damage to hearing is caused by long continued exposure to sounds above 80 decibels (the level of city traffic), so an 8-decibel reduction over a long time could cause a meaningful reduction in damage.

Conclusion

Measuring the cumulative health benefits of the Copernicus Science Centre's green roof is difficult, given that visitors spend a relatively short portion of their lives inside it. However, it showcases the ability of green roofs to absorb less heat than traditional ones and act as mild sound buffers. As shown by the Science Centre, particular plants can be chosen for their ability to survive in a 'rooftop' environment without sacrificing these benefits. 10

Recommendations

Structured EU investment in green roofs would spread these benefits to more of the population, alongside additional advantages not mentioned in this case study (green roofs remove pollution, moisten and cool the surrounding air, provide attractive and calming spaces for the public, and serve as a habitat for birds and insects – the Science Centre even had a duck nesting on it!). This is particularly important due to higher summer temperatures projected for Europe in the future, and the rarely-mention threat to public health posed by noise pollution.

Adapted from a page on the Copernicus Science Centre's website: http://www.kopernik.org.pl/en/exhibitions/ogrod-na-dachu/rosliny/

Blood pressure and parks in Kaunas, Lithuania

Synopsis

A combination of factors leads to high blood pressure, associated with a shorter lifespan and lower quality of life. Two studies in Kaunas, Lithuania, suggest that living near to and using green spaces may help promote a healthy blood pressure.

Background

7.3% of Kaunas' land area is dedicated to parkland. Two studies were undertaken within the framework of the PHENOTYPE, a research project funded through the European Commission, whose aim is to search for robust evidence of the health benefits that exposure to the natural environment can bring from outside of north-western Europe and the USA (where the bulk of studies have been conducted to date). Both took place in Kaunas. One focussed on women in the early stage of pregnancy and their distance from green spaces, the other on patients with coronary artery disease (CAD) and the effect of physical activity in green spaces on their health.

Problems

Studies suggest that pregnant women as a group are susceptible to blood pressure disorders. The study on pregnant women showed that the risk of developing hypertension (high blood pressure) increased by 9% for individuals with normal blood pressure and by 14% for individuals with high-normal blood pressure for every 300m further away they lived from green spaces. High blood pressure (for pregnant women and other demographic groups alike) can lead to a build up of plaque in the arteries, the end result of which is coronary artery disease (CAD).

Solutions

The study on pregnant women suggested proximity of their place of residence to green spaces was associated with lower blood pressure. There are various explanations for why living near green spaces may be good for blood pressure:

Both have positive effects on the cardiovascular system and physiological stress. The study on exercise for CAD patients showed that the same amount of exercise (a 30 minute walk a day for seven days running) had a greater positive effect on cardiac function (including blood pressure) if it was undertaken in a park, than if it was undertaken in an urban environment.

- It can increase recreational physical activity,
- It can foster social contacts

Conclusion

Cardiovascular disease, an umbrella term for all diseases of the heart and circulation, is the number one cause of death globally. The Lithuanian studies above show that green infrastructure in the form of parks and green spaces can both combat both high blood pressure, a risk factor for CAD (the most common form of cardiovascular disease), and benefit the health of patients already suffering from it. These benefits depend on green spaces being accessible.

Recommendations

The EU should protect existing green spaces and create new ones to ensure that all residents of urban areas have easy access to them.

Alnarp rehabilitation garden: green infrastructure and psychiatric care in Sweden

Synopsis

A rehabilitation garden was created in the Swedish village of Alnarp to research the role nature plays in improving mental health. Patients treated there ended up spending less time in hospital and requiring less primary treatment, and felt that their health and wellbeing had improved as a result.

Background

Each year, over a third of the EU's population experience mental disorders, and under a third of all cases receive treatment. These include stress-related illnesses which are harmful to both individual physical and mental health, and on a social level, having a negative impact on sufferers' interactions with others. The garden in Alnarp was set up in 2001 by the Swedish University of Agricultural Sciences as a project to research nature-based rehabilitation as a solution to these stress-related disorders. Its design was informed by supporting environment theory, which is based on the assumption that human beings are adapted to a life close to nature in social and cultural interaction with a limited number of people. Patients are normally admitted for therapy programmes for a period of three months for four days a week. These programmes involve a range of activities, from less demanding ones which involve walks and sensory interaction with plants and features of the garden, to more demanding physical activities like gardening, cooking and handicrafts.

Problems

A 2011 Swedish Social Insurance Agency Report stated that the most common disorders responsible for people taking sick leave from work were stress-related illnesses such as depressive episodes. Sweden has seen a marked increase in the share of sickness absences caused by psychiatric disorders. For sufferers of these illnesses, not feeling able to meet the demands of the surrounding world or perform one's normal daily occupations gives rise to negative feelings such as life being meaningless. The case for many forms of rehabilitation is weak, with evidence suggesting that counselling, exercise, multimodal medical rehabilitation and return-to-work programmes do not result in more people returning to work after treatment.

Solutions

Finding meaning in everyday life is one of the core foundations of good health and well-being, and arguments have been made that an essential prerequisite for experiencing meaning is the perceived value of daily occupations. In general, nature-assisted rehabilitation has shown itself to be as effective as, or more effective than, 'traditional' rehabilitation methods. A study (Pálsdóttir et al., 2013) found that after 3 months of rehabilitation, one group of patients experienced the following improvements:

- Managing everyday occupations at their own pace
- Actively seeking social interaction with friends
- Resuming or taking up creative occupations
- A conscious appreciation of nature for mental recovery

A separate study (Währborg et al., 2014) found that for another group of patients, undergoing therapy (normally for 3 months) in Alnarp has resulted in decreased healthcare consumption, measured in terms of decreasing number of healthcare appointments and inpatient das in psychiatric healthcare after the rehabilitation in Alnarp.

Conclusion

The Alnarp garden showcases nature-assisted rehabilitation as an effective tool to treat stress-related mental illnesses. This benefits the patients by improving their health, society through renewed productivity of its workforce, and the public health budget by reducing money spent on primary care and accommodation in hospital. The study by Pálsdóttir et al. shows that nature continues to play a role in supporting mental well-being even after treatment.

Recommendations

Nature-assisted rehabilitation is a worthy recipient of continued EU funding and research. Nature continues to support mental health benefits outside rehabilitation gardens too, therefore natural areas should be preserved and restored to ensure that all of the EU's population has access to them.

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See also

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The MA 48's climate facade in Vienna

Synopsis

A building belonging to the Vienna Magistrate (MA 48) was chosen as the site for a new green wall. A research project monitoring the wall found that it delivered multiple health benefits. The project contributes to a trend of similar initiatives in Vienna.

Background

Cities are hotspots for both poor air quality and high temperatures (the urban heat island effect). The ability of plants to absorb both particles of pollution and heat is well documented. In Vienna, anyone installing green walls can apply for subsidies of up to €2500, and a practical guide for facade greening has been developed. In 2011 an 850m² green wall was constructed on the facade of the Agency for Waste Prevention and Separation. Since this several more public and private facade greening have been planned or initiated.

Problems

Despite Austria's overall high level of wellbeing, air pollution is still a problem in many provincial capitals. In 2014, the Organisation for Economic Cooperation and Development published a ranking of cities by air quality, in which Vienna scored 2.5 out of ten, just 0.5 more than Voralberg, Austria's most polluted city, and far behind London, which scored 6.3.

Enclosed spaces in cities devoid of natural materials can get very hot, and climate change is exacerbating the problem. In 2018 the temperature on the metro in Vienna reached 35°C; under EU law it would not even be legal to transport cattle at this temperature. Not all sites are suitable for planting trees to alleviate both of these problems. Where trees can be planted, if they are situated in narrow street canyons, they may actually prevent pollution from dispersing. Building facades require maintenance (e.g. window cleaning) which costs money and creates jobs.

Solutions

Using the vertical facade of the building as a greenable surface offered a way around the lack of space. Green walls absorb particulate pollution like trees, but unlike trees they do not prevent it from dispersing upwards out of harm's way. During summer, the cooling effect of the building's green 'skin' was equivalent to 45 air conditioning units operating 8 hours a day, or four 100-year old beech trees. As well as this, the plant matter insulated the building, and heat loss was reduced by up to 50% during winter. Research on the green wall's contribution

to air quality is ongoing. Maintenance of the facade costs no more than if it were made of glass, and likewise creates jobs.

Conclusion

Green facades are an affordable, multipurpose tool with benefits for human health. The heat reduction potential of the MA 48 wall has already been shown, and given past research on how plants mitigate pollution, there is every reason to expect that monitoring will show an improvement on this front too. The MA 48 is an important initial step in a structural change which is increasing the amount of green surfaces in Vienna, and the positive effects should scale up with every new green wall built.

Lessons learned

One-off green infrastructure health projects aimed at improving air quality and temperature are not isolated and futile measures if they can be turned into pilot projects, used as an opportunity to measure this approach's benefits, and replicated by support structures such as subsidies and information manuals.

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The ESIKOTO project: integration through nature in Finland

Synopsis

ESIKOTO project (2016–2018, http://www.metsa.fi/esikoto) is one of the rare projects in Finland funded by the European Social Fund (ESF) where focus group are asylum seekers and persons who recently received residence permit. Funding for the project comes from the priority goal 5 of the ESF which aims at strengthening social inclusion and preventing poverty. The main aim of the ESIKOTO project is to involve this group of people in meaningful activities which promote integration and enhance bonding with the rest of the society, as well as prevent institutionalization. Meaningful activity can mean such which aims directly at asylum seekers, but the purpose in this project is more to guide them to find existing activities in which they can participate in the same way as other members of the society. Particular focus is on the asylum seekers' engagement in planning of activities, as well as active participation.

Background

Resources of the reception centres are usually enough to only meet the basic needs such as living and food, but also language, social and cultural skills teaching. However, asylum seekers, of whom many will become local residents, need in addition to engagement in hobbies also preparations for stepping into the world of work.

Pre-integration period is currently not utilized as effectively as possible and participation of the asylum seekers in the society is low. Their role has been largely passive and opportunities for participation are almost non-existing, or not enough information about these is available (Enoranta 2007). By systematically modelling the pre-integration process regionally and by developing opportunities, tools, materials and know-how, it is possible to achieve more efficient pre-integration process for asylum seekers, as well as for the Finnish society.

Objective

The main objective of Parks and Wildlife Finland in the ESIKOTO project is to identify ways of how natural environment can play an active role in the pre-integration process. During the two-year long project this is going to be achieved by increasing the awareness of health and well-being impacts of natural environment among asylum seekers, professionals and voluntary organisation members; by organising outdoor activities together with the voluntary sector and framing the best performing practices into a tool to be used by professionals; by producing the information package about Finnish nature which is to be used by asylum seekers in order to benefit from natural environment while waiting for the residence permit decision; and by encounters between asylum seekers and other members of the society. ESIKOTO project's

main focus group are asylum seekers from five different reception centres within Northern-Ostrobothnia region – three in Oulu, one in Pudasjärvi and one in Kuusamo.

Outcomes

As the ESOKOTO project is still ongoing (2016 - 2018), there are not any final evaluations as of today. However, a workshop and a questionnaire undertaken with asylum seekers showed that outdoor activities and nature trips are important to this group and missing in their everyday lives, but a lack of information made them uncertain of going outdoors independently. Many participants found the cold Finnish winter hard to cope with.

Lessons learned

The difficult situation in which most asylum seekers exist can be remedied by giving them better opportunities to integrate into local culture and society, and nature is a tool for doing this. Good information must be provided on how to get the most out of nature and how to prepare for trips given unfamiliar features of the host country (e.g. cold weather). Since nature is an integral part of Finnish identity, learning to make use of it is an important step in integration that cannot be made without help on the part of the hosts. Given its ability to reduce stress and improve mood, nature is a particularly good tool to promote social relations between asylum seekers and host countries.

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Blue-green infrastructure in Philadelphia, Pennsylvania

Synopsis

In Philadelphia, neighbourhood physical conditions have been associated with mental illness and may partially explain persistent socioeconomic disparities in the prevalence of poor mental health. The objective of the 'Green Vacant Land'-project is to evaluate whether interventions to green vacant urban land can improve self- reported mental health.

Background

Almost 1 in 5 US adults report some form of mental illness. Depression is the second largest contributor to years lived with disability in the United States, with more than 16 million adults experiencing an episode annually. Yet patient mental health services only account for an estimated 5% of total medical care spending in the United States. A broadening of treatment options to improve mental health is necessary, including interventions that fundamentally change harmful environmental surroundings that may be key contributors to mental illness.

Neighbourhood physical conditions, including vacant or dilapidated spaces, trash, and lack of quality infrastructure such as sidewalks and parks, are associated with depression and are factors that may explain the persistent prevalence of mental illness in resource-limited communities. Vacant and dilapidated spaces are unavoidable neighbourhood conditions that residents in low-resource communities encounter every day, making the very existence of these spaces a constant source of stress, and possibly mental illness.

However, neighbourhood physical conditions can also positively influence mental health. Spending time and living near green spaces have been associated with various improved mental health outcomes, including less depression, anxiety, and stress.

Methods

This city wide cluster randomized trial examined 442 community-dwelling sampled adults living in Philadelphia, Pennsylvania, within 110 vacant lot clusters randomly assigned to 3 study groups. Participants were followed up for 18 months preintervention and postintervention. This trial was conducted from October 1, 2011, to November 30, 2014. Data were analysed from July 1, 2015, to April 16, 2017.

The greening intervention involved removing trash, grading the land, planting new grass and a small number of trees, installing a low wooden perimeter fence, and performing regular

monthly maintenance. The trash cleanup intervention involved removal of trash, limited grass mowing where possible, and regular monthly maintenance. The control group received no intervention.

Outcomes

Self-reported mental health measured by the Kessler-6 Psychological Distress Scale and the components of this scale.

A total of 110 clusters containing 541 vacant lots were enrolled in the trial and randomly allocated to the following 1 of 3 study groups: the greening intervention (37 clusters [33.6%]), the trash cleanup intervention (36 clusters [32.7%]), or no intervention (37 clusters [33.6%]). Of the 442 participants, the mean (SD) age was 44.6 (15.1) years, 264 (59.7%) were female, and 194 (43.9%) had a family income less than $25 000. A total of 342 participants (77.4%) had follow-up data and were included in the analysis. Of these, 117 (34.2%) received the greening intervention, 107 (31.3%) the trash cleanup intervention, and 118 (34.5%) no intervention. Intention-to-treat analysis of the greening intervention compared with no intervention demonstrated a significant decrease in participants who were feeling depressed and worthless, as well as a nonsignificant reduction in overall self- reported poor mental health. For participants living in neighbourhoods below the poverty line, the greening intervention demonstrated a significant decrease in feeling depressed. Intention-to-treat analysis of those living near the trash cleanup intervention compared with no intervention showed no significant changes in self-reported poor mental health.

Conclusion

Among community-dwelling adults self-reported feelings of depression and worthlessness were significantly decreased, and self-reported poor mental health was non-significantly reduced for those living near greened vacant land. The treatment of blighted physical environments, particularly in resource-limited urban settings, can be an important treatment for mental health problems alongside other patient-level treatments.

Reference

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Effects on mental health of moving to greener and less green urban areas in the UK

Synopsis

Despite growing evidence of public health benefits from urban green space there has been little longitudinal analysis. This study used panel data to explore three different hypotheses about how moving to greener or less green areas may affect mental health over time. The samples were participants in the British Household Panel Survey with mental health data (General Health Questionnaire scores) for five consecutive years, and who relocated to a different residential area between the second and third years. Fixed-effects analyses controlled for time-invariant individual level heterogeneity and other area and individual level effects. Compared to pre-move mental health scores, individuals who moved to greener areas had significantly better mental health in all three postmove years, supporting a "shifting baseline" hypothesis. Individuals who moved to less green areas showed significantly worse mental health in the year preceding the move but returned to baseline in the postmove years. Moving to greener urban areas was associated with sustained mental health improvements, suggesting that environmental policies to increase urban green space may have sustainable public health benefits.

Background

Unipolar depressive disorders are now the leading cause of disability in middle to high income countries, making mental health and wellbeing a critical modern public health issue. This trend may be related to increased urbanisation, with 77.7% of people in the world's more developed regions now residing in urban areas, and to reduced access to "natural" spaces which aid stress reduction. Support for this possibility comes from epidemiological studies which find that individuals living in the greenest urban areas tend to have better mental health than those in the least green areas. Similar patterns are found for a range of physical health outcomes, including mortality. Experimental findings and field observations on the effects of green space exposure on psychological health are also consistent with this epidemiological evidence.

However, to date most epidemiological research has used cross-sectional data which limits causal inferences. Are people happier and healthier due to the proximity of green space to their homes, or do healthier people move to greener areas? Such selective migration might result from people who are already more physically active moving to areas that provide exercise opportunities, or the higher incomes of people with good mental health enabling them to pay

higher housing costs in greener areas. Recent analysis of repeated measures data from the British Household Panel Survey (BHPS) has begun to address these possibilities.

Methods

Adult samples were drawn from the BHPS, a nationally representative longitudinal survey of over 5000 UK households that ran annually from 1991 to 2008. The analyses investigated GHQ scores of two subsets of respondents: those who moved to greener urban areas, and those who moved to less green urban areas. Estimation samples were limited to English residents, and BHPS respondents from Wales, Scotland, and Northern Ireland were excluded, as data on local area green space was from a database which covered only English residential areas. Relocations were also restricted to those within urban areas to avoid confounding green space with urbanity. Analyses used balanced panels with full data for six consecutive data waves, where the first three waves were in one location, and the last three were in the other.

Mental health was measured with the short-form twelve item General Health Questionnaire (GHQ), a self-report instrument used to aid diagnosis of disorders such as anxiety and depression. Respondents report how they have felt in the "past few weeks" compared to "usual" for six positive mood states, such as being able to concentrate and make decisions, and six negative mood states, such as feeling under strain and lacking confidence. Two categories of individual were identified: (a) those who relocated to greener areas, and (b) those who relocated to less green areas, and examined the mental health of these groups before and after their moves.

The level of greenness around their pre- and post-move homes was derived from the Generalized Land Use Database for England (GLUD), as in earlier research in the UK. GLUD classification of high resolution land parcels was distributed to 32 482 lower-layer super output areas (LSOAs) across England, each encompassing approximately 1500 residents.

Outcomes

There were some differences in the two groups of movers . For instance, on average, movers to greener areas were slightly older than movers to less green areas, more likely to be married, more likely to be retired, less likely to live in a detached house, and more likely to be non-commuters (29.97% vs 25.74%). Movers to greener areas, who were currently living in less green areas, also had lower mean (inverse) GHQ scores than movers to less green areas, who were currently living in more green areas. This baseline difference reflects previous findings of better mental health in greener urban areas.

Importantly, move motives were highly similar across the two samples. By far the most frequent motive was "larger accommodation", stated by 25.6% of those who moved to a greener area and 21.7% of those who moved to a less green area. Among movers to greener areas, only 4 respondents indicated that area greenness was a reason for the relocation though a few did include factors such as noise and traffic, both of which may be related to local area green space. Again, though, these motives were present in similarly low frequencies among movers to less green areas.

Conclusion

This study aimed to explore the longitudinal effects of changes in environmental green space on mental health through examination of the impact of home relocation to a greener (or less green) urban area. Previous cross-sectional work suggested mental health is better in greener urban areas, and previous estimates from within-individual differences showed that 'on average' mental health improved during years of residence in greener areas. However, this average could reflect a range of different temporal patterns following changes in residential area green space which have different implications for environmental urban design and land use policy. Take the case of relocation to a greener urban area. There may be an initial peak in mental health following the move to a greener area before adaptation takes place and people return to premove levels (i.e., the adaptation hypothesis). Such a process implies time-limited benefits from urban green space development. Alternatively, it may take time to accrue the mental health benefits from moving to a greener area and thus the initial years will show little immediate impact (i.e., the sensitization hypothesis). This implies that initial benefits to mental health from urban greening might be maximized when developments are accompanied by information campaigns, and health or lifestyle promotion work. Finally, the impact might be immediate and sustained, and result in a relatively rapid shift in baseline mental health after a move (i.e., the shifting baseline hypothesis). This scenario implies immediate and potentially long-lasting benefits to local residents from urban green space development. As noted earlier, all three processes have been witnessed following other life changes and thus we were unable to predict, a priori, which pattern might explain previous green space related findings.

The test of these different possibilities suggested that for movers to greener areas, the shifting baseline hypothesis best fit the data: Mental health improved within a year and stayed approximately the same for the following two years. Results for movers to less green areas were less straightforward: The predicted decline in mental health for this group occurred before the move and was followed by rapid adaptation to the new circumstances. There are at least two possible interpretations.

First, the anticipation of moving to a less green area may have negatively impacted mental health. Such negative anticipation effects are observed preceding divorce, for instance. Second, declines in mental wellbeing may have precipitated the moves themselves. For instance, it could be that individuals who were becoming increasingly unhappy in greener areas, perhaps due to fewer facilities or job opportunities, decided to move to less green urban areas and once they had done so their mental health improved again. Although possible, move motivations were broadly similar across the two samples and employment related reasons, for instance, were rare among movers to less green space. Thus, at least with the current data, it is difficult to offer move motivation as an explanation for the findings.

Confidence in the results comes from the negative effects on mental health of other life changes included in the analyses such as unemployment and ill-health which have also been demonstrated in previous research. The negative relationship observed between area level education and mental health among movers to greener areas may reflect increased stress from living among a new peer group of higher socio-economic status, but this is highly speculative at this stage. The relatively small samples of observations used in the regressions possibly accounts for why some control variables shown in previous work with the BHPS data set to be significantly related to GHQ, such as marital status, were not significant in these estimations.

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An ecological study investigating the association between access to urban green space and mental health in Auckland, New Zealand

Synopsis

This study aimed to find whether proximity to urban green spaces is associated with human mental health. A cross-sectional examination of the relationship between access to urban green spaces and counts of anxiety/mood disorder treatments amongst residents (aged 15 years and over) in Auckland City, New Zealand. Anxiety/mood disorder treatment counts by three age groups were aggregated to 3149 small area units in Auckland. Six measures of green space access were derived using GIS techniques involving total green spaces and useable green spaces. Negative binomial regression models have been fitted to test the relationship between access to green space and area-level anxiety/mood disorder treatment counts, adjusted for age and area-level deprivation. Anxiety/mood disorder treatment counts were associated with three green space measures. The proportion of both total and useable green space within 3 km and distance to nearest useable green space all indicated a protective effect of increased access to green space against anxiety/mood disorder treatment counts.

Background

As many cities experience poor air quality, water pollution, heat island effects and crowding,1 it is unsurprising that the physical and increasingly, the mental health of urban residents has become of major focus in recent decades. One area of investigation is the relationship between access to urban green space and both physical and mental health benefits. An 'integrated area comprising natural, semi natural, or artificial green land', urban green space provides an aesthetic place for social and recreational opportunities, which encourages physical activity, enhances social ties and promotes mental and physical recuperation.

Importantly, studies in New Zealand found no association between green space and a number of health outcomes, including physical health and cause-specific mortality. This suggests that green space and any associations with health outcomes may vary between environments and social contexts, for example the role of green space is likely to be more influential within urban environments in contrast to rural areas. Green space research concluded that New Zealand's relative prevalence of natural, green environments and a culture of 'outdoor holidaying' in comparison to other regions may reduce the ability to detect associations with health outcomes. However, this claim has not been evaluated in relation to mental health. A review of

health associations with urban green space concluded that many claims are supported by weak evidence and studies were limited by poor design and failure to exclude confounding factors and bias.

Given this background, the authors of the study aimed to understand the relationship between anxiety/mood disorder treatment and access to green space in an urban setting in New Zealand. To our knowledge, this is the first study to evaluate this relationship in New Zealand. Using a data compiled by Richardson et al. (2010), the authors classified green space as either total or useable, to untangle the potential role of active involvement vs observation of green space. The study did not rely on self-reported mental health data, an improvement over many studies in this field. Instead, data from a linked database of all national administrative databases was used.

Methodology

Geographical Information System (GIS) techniques were used to investigate the spatial relationships between green space access and mental health treatment at the meshblock (MB) level, New Zealand's finest aggregation unit. The authors included 3149 of 3247 MBs in Auckland City (excluded Islands). Auckland City was chosen for a number of reasons. Firstly, it is the largest and fastest growing city within New Zealand. Secondly, meshblock are typically homogeneous in size (on average 0.04 km2), making comparisons across the city more equivalent. Thirdly, Auckland has relatively high levels of green space across the city. Finally, healthcare facilities are evenly distributed throughout the city so access to treatment should not be a significant issue.

Outcomes

It is hypothesized that green space has positive effects on mental health both through active participation and as a salutogenic environment. This study attempted to quantify these two causal pathways by identifying green spaces as useable or non-useable and total. The study found that better access to green space was associated with a decrease in anxiety/mood disorder treatment counts. Specifically, higher proportions of surrounding green space in the broader neighbourhood and decreased distance to useable green space, were associated with lower levels of anxiety/mood disorder treatment. These results are consistent with a number of other studies, which also found positive associations between mental and general health indicators and the proportion of green space within a 3 km buffer. It is unknown whether green space accessibility through a road network has previously been associated with specific

indicators of mental health, however a study using an unidentified access measurement identified that individuals living away from green space were more likely to be stressed.

The results of this study support two pathways through which green space can have positive effects on mental health. The first identifies the potential salutogenic effect of green space in the broader neighbourhood. As the authors did not find an association between the proportion of green space within 300 m buffers and mental health, perhaps the green- ness of the wider neighbourhood may be more influential than the immediate environment and large areas of green space may provide more restorative effects,20 potentially through visualization of greenness. This view differs with findings by Maas et al. (2009) who found that the proportion of green space within 1 km was more strongly associated with anxiety/depression measures than the proportion within 3 km. However, their findings were only significant in 'slightly urban areas' and no association between green space and disease prevalence was found in highly urban environments. It is worth noting that since fewer areas contained green space within 300 m, the lack of variation may have limited our ability to detect a significant association. It is also possible that the exclusion of private gardens may be responsible for no significant findings within 300 m. Green space within the immediate vicinity may be more important for mental well-being than local neighbourhood green space. Cultural and climatic variables are recognized to influence green space perception in urban environments and this may be partly responsible as to why the findings of this New Zealand conducted study differ to others.

Conclusion

This study identified the need for further investigation into the potential impact time of exposure to green space on any associated health outcomes. Data on length of residence at the individual level and utilizing individual health outcomes would be an improvement over the current research. The study would also benefit by incorporating sex and ethnicity as confounding factors. Richardson and Mitchell (2010) stress that health benefits cannot be 25 assumed constant across population subgroups and this should be taken into account when recognizing health benefits. In addition a more detailed green space dataset obtained through satellite imagery classification would allow smaller, localized green space features to be represented and it has been suggested that personal garden space reduces the protective effects of neighbourhood greenness. Finally, repeating this study in an environment with highly contrasting levels of useable and non-useable green space would allow us to separately examine the effect of actively using green space vs passive immersion or visualization.

Furthermore, indicators of green space quality should be included as this may influence usage, but may need to be population- specific.

This study shows that the presence of green space in urban environments may decrease anxiety/mood disorders. Increasing quantities of green space would result in benefits to the population as well as potential reductions of pressure on healthcare facilities. As mental illnesses contribute significantly to population morbidity, these results and future work should be considered by urban designers and town planners as well as inform policy and management decisions.

Reference

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