Landscape and Wellbeing: future research thoughts

景观与福祉：未来研究思考

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Abstract

Throughout history, the landscape around us has been recognised for its myriad contributions to human wellbeing. This health-enhancing (salutogenic) aspect of landscape has become ever more important as we become an increasingly urbanised society and people live in contexts divorced from access to natural environments. However, modern science and policy-making requires high standards of evidence to justify investment in enhancing access to salutogenic landscapes and this, in turn, requires new ways of understanding the pathways and mechanisms that link the experience of the natural environment to specific (and often multiple) health outcomes. This paper describes the development of innovative and multi-disciplinary approaches to researching such links, drawing on experience from OPENspace research centre and its collaborators, and looking forward to where innovative approaches might offer further enlightenment in future. It describes pioneering work that draws on environmental psychology, health geography, epidemiology, expertise in psychoneuroendochrine mechanisms and neuroscience, for example, to illustrate ways that collaborations across disciplines, geographies and timescales have recently produced new ways of understanding the relationship between landscape and health. It discusses the concept of the exposome and its implications for research, including epigenetics, the lifecourse of place, and the many influences of the microbiome. It points to future challenges and research opportunities, including new methods both for collecting and for analysing data, and their potential to inform policy and practice in planning, designing and managing health-enhancing landscapes.

摘要：本文依托 OPENspace 研究中心及其合作团队的研究积累，梳理了用于探究景观—健康关联的跨学科创新研究体系，并展望创新研究方法在未来的探索方向。文中列举多项前沿交叉研究：融合环境心理学、健康地理学、流行病学、心理神经内分泌学、神经科学等专业理论，证实跨学科、跨地域、跨时间尺度的协同研究，近年已催生出解读景观与健康关系的全新范式。文章探讨暴露组概念及其研究意义，涵盖表观遗传学、场所生命历程、微生物组多重影响等维度；同时指明未来研究面临的挑战与潜在方向，包括新型数据采集、数据分析技术，以及这些方法如何为健康型景观的规划、设计与管理提供政策及实践层面的支撑。

Keywords:landscape, wellbeing, health, salutogenic, research methods, exposome, lifecourse of place, environmental psychology, health geography.

关键词：景观；福祉；健康；有益健康导向；研究方法；暴露组；场所生命历程；环境心理学；健康地理学

Introduction

In reflecting on future research directions and opportunities for understanding the links between human health and the space we inhabit, I am reminded how much we find ourselves in recursive loops of understanding as we explore these fundamental questions that have engaged people throughout history. People have always recognised, at some level, that the landscape around us not only offers us food and water, air to breathe and places of shelter, but also makes a difference to how we feel and opportunities for development: it can allow us to flourish to the best of our potential or harm and diminish our ability to survive, let alone thrive. For this reason, landscapes that support flourishing have been recognised, idealised and even sanctified in many different cultures and locations in space and time (Ward Thompson, 2011; 2023). Therapeutic landscapes and working or spending time in them were often seen as sources of health and recovery from illness (Gesler, 2003). As we have become more urban as a species, now leading predominantly urban lifestyles across most parts of the world, we have created artificial, constructed spaces in which to live our lives. These have brought us many good things, such as better shelter and access to resources, which have enhanced health, but also many bad things, such as overcrowding, opportunities for disease to spread rapidly, and limited access to the natural environment, which have harmed health. In the nineteenth and early twentieth century (drawing on seventeenth and eighteenth century concepts of aesthetics, such as beautiful, sublime and picturesque landscapes) urban planners, designers and managers made a difference to human health through their plans for towns and cities (Ward Thompson, 2011). Access to clean water, efficient disposal of foul sewage, and access to green spaces, relatively unpolluted air and sunlight through regulation of building standards and public park provision made a real difference to health at all stages in people's lives (Worpole, 2007). In the twentieth century, development of antibiotics and other pharmacological innovations, alongside major clinical advances in diagnosis and treatment, had a huge impact on the likely survival of humans from birth into old age, doubling life expectancy from 1900 to 2000 (Dattani et al., 2023). This, in turn, led to a change in the demographic profile as the changes permeated across countries and cultures. By the end of the twentieth century, the global population showed an ageing profile quite unlike almost all other species, including our own, throughout history (Roser, 2019) and the emphasis on health improvement, certainly for developed countries, was predominantly clinical. Yet the seeds were already being sown by pioneers like the environmental psychologists, Rachel and Stephen Kaplan (1989; 1998) for a renewed interest in ways that planning and designing the physical environment, especially the environment that was accessible to, and used by, most people in their everyday lives, could make a difference to wellbeing and enhance health.

When we initiated OPENspace in 2001, we tried to engage with people in different health sciences but found it difficult to interest clinicians in robust research that showed how the physical environment, and particularly the outdoor environment that was our focus (two of its founding directors, Simon Bell and I, are landscape architects by profession), could enhance health. We wanted to understand how outdoor environments make a difference to people going about their everyday lives, but this is a challenge for conventional health research where clinical trials based on randomised, controlled allocation of participants to different exposures is the "gold standard". While such 'randomised, controlled trials' are appropriate for testing new pharmaceutical treatment they are neither appropriate nor ethically possible to undertake with people living in their usual home environments. We needed to develop robust ways of working with participants to understand how they perceived and responded to the outdoor environments they encountered; we also needed to obtain more independent measures of those responses (less susceptible to reporting bias of any sort) that would help explain the mechanisms or pathways behind any such response, and that in turn would be meaningful to health researchers and public policy-makers. We were fortunate to have an environmental psychologist, the late Peter Aspinall, with us as co-director of OPENspace from the start and he inspired many innovative ways of working with participants using projective approaches (often based on George Kelly's pioneering work in personal construct psychology (Kelly, 1955)) and sophisticated statistical analysis to explore our research aims. Such multi-disciplinary collaboration has been core to our work in seeking to understand better how landscape and wellbeing are linked and the potential for creating salutogenic (health-enhancing) places and spaces. We have been fortunate to work with many expert and pioneering researchers both within and beyond our own research team, including health geographers, epidemiologists, neuroscientists, sociologists, gerontologists and geriatricians.

One early and fruitful collaboration involved working across landscape planning, environmental psychology, health geography, geographic information systems (GIS), psychophysiology and biostatistics to research links between access to green space such as parks and publicly accessible woodlands and physiological biomarkers of stress (Ward Thompson et al., 2012; Roe et al., 2013). We were able to demonstrate evidence of patterns reflecting healthier psychoneuroendochrine mechanisms in a sample of job-seeking participants living in deprived urban communities who had more access to green space compared to those with less green space in their home neighbourhood. These findings were enhanced by triangulation with participants' self-reported levels of stress, showing that lower stress reflected healthier biomarkers and higher levels of green space mapped via GIS. This pioneering research attracted interest from the World Health Organisation, inter alia, (Ward Thompson & Silveirinha de Oliveira, 2016) and led to further collaborations internationally and across disciplines, including ongoing work with our OPENspace Visiting Professor, Jenny Roe (Ward Thompson et al., 2016). It also highlighted the opportunities and challenges in seeking better understandings of the pathways by which the landscape – outdoor space and the natural world encountered there – can support good health, and the psychophysiological mechanisms by which this happens (Markevych et al., 2017). It seems clear that multi- and inter-disciplinary work is needed to advance such research and promising new avenues continue to open up when approached in this way.

An over-arching concept that is increasingly being used to consider links between health and environment is that of the 'exposome'. This concept, first proposed in 2005, encompasses all exposures to which an individual is subjected, from conception to death (Wild, 2012) and addresses all those influences on health that are not gene-based. It was developed in part to help tease apart factors in the human 'nature vs nurture' debate on health outcomes, where opinions differ and/or evidence is unclear on the relative roles of genetics and environmental exposures. While Wild's definition includes processes internal to the body such as metabolism, hormonal regulation, etc., which may appear to be of less direct relevance to studying salutogenic landscapes, it also includes exogenous exposures, from air pollution and contagious diseases to sunlight and vegetated space, as well as the wider societal contexts in which people spend their lives and the social, economic and psychological influences of these. In practice, such distinctions between types of exposure may not be so clear-cut and there is evidence that external biochemical exposures, for example, may lead to internal changes in metabolism or psychophysiological response (Lou et al., 2023). Epigenetics, in particular, involves studying the way the environment influences the expression of genes without altering the DNA of an individual, and underlines how complex the interplay between gene and exposome is (Thayer & Kuzawa, 2011). While studies of the exposome require researchers with many different kinds of expertise, they can potentially add hugely to our understanding of what makes a healthy space and why that is so. They can also contribute to understanding how an individual's exposure to different places (especially places where they live and work) over the course of their lives can lead to different health outcomes, particularly as people approach older age, e.g. Argentieri et al's study of the relative roles of the genome and exposome in ageing and mortality in the UK (Argentieri et al., 2025). Colleagues in health geography have pioneered some of this research into the 'lifecourse of place' and there remain many potentially fruitful avenues for research here (Pearce et al., 2018).

One of the challenges in this kind of research lies in identifying what the critical factors might be in mapping the exposome in time and space. How does getting outdoors in different contexts affect exposure to sunlight, ultra-violet (UV) rays and vitamin D production, for example? What does exposure to wind and rain, trees, herbs and fungi, animals such as dogs or rats do, for good or ill, in relation to chemical and biological compounds which may be harmful, beneficial, or a complex combination of the two (influencing asthma, for example)? And does it matter what lifestage we're at when these exposures happen? There is increasing evidence that exposure to different elements of the environment play a vital role in Immune system functioning, where exposure in utero and in the first few months of life may be crucial (Kuo, 2015; Pierau et al., 2021). Researching airborne elements of the exposome is becoming a particular area of expertise and wearable devices that can capture such exposures are increasingly being considered. For example, dynamic exposure to airborne biological and chemical compounds over several years and locations, using wearable devices in the US Bay Area, have been explored by Jiang et al (2018). However, even these studies cannot consider the whole lifecourse but usually only a brief period of weeks or months at best. In addition, they may only capture elements of physical exposure for analysis, without considering also the psycho-social or psychophysiological dimensions of environmental experience. Yet we know that maternal exposure to varying levels of green/blue space in the living environment is associated with different birth outcomes in terms of healthy weight and gestational maturity and it seems likely that this reflects the maternal psychophysiological response to such places as well as more specific biochemical pathways (Dadvand et al., 2014; Grazuleviciene et al., 2015).

Discussion of these issues highlights the need for contributions from many disciplines to understand environmental exposures, measure them accurately and interpret them meaningfully, in order to add insights into the potential mechanisms by which such exposures affect health. It also underlines the importance of considering what kinds of data to collect, how to collect them effectively for different populations in different contexts, where and when to collect them and, in the latter case, at what scale or level of granularity in time and space.

One area in which there has been a burgeoning of interest is neuroscience, where early work promoted by the environmental psychologists in our team took advantage of mobile headsets that had only recently become available for use in the field, as opposed to the laboratory. Use of such tools offered the intriguing possibility to record responses, as they occurred in the brain, to moving through real outdoor environments. Such research 'in the wild' – in the real, everyday kinds of spaces that people encounter in their daily lives - was pioneering in beginning to reveal patterns of neural response that could be associated with walking in green and natural environments, for example, as opposed to busy urban streets. This gave ecological validity to interpretations of neural response to the exposome, by contrast with the reliance on visual experience that predominates in virtual reality (VR) labs. Our work allowed for sensations beyond the visual, such as sounds, smells, touch and taste, exposure to inhaling/swallowing airborne particles, as well as the social experience of different places, to inform the captured neural signals (Aspinall et al., 2015; Roe et al., 2013; Neale et al., 2017). A major challenge in such studies is how to interpret the neural patterns (Gramann, 2024) and (as always with environmental exposures) identifying which exposures are most likely to have contributed to the neural response and how long any effect or lag in response might continue. Nonetheless, this seems a fruitful area for further research and one in which we continue to engage collaboratively with neuroscientists.

In parallel with mobile neuroheadsets, other technological advances in recent years have led to ever-expanding opportunities for wearable devices to be used to capture data on the exposome. As exemplified in Jiang et al.'s work (2018), these can not only be used by researchers moving through different environments but also be part of citizen science approaches, where research participants agree to collect the data themselves, potentially enhancing the sample size considerably for exposome research. Of course, some data of this sort has already been collected via wearable technology for a number of years now: the use of pedometers, accelerometers, and associated IT applications that allow individuals to map both the locations and levels of their physical activity have been much popularised and can be drawn on for research (Fitzsimons et al., 2008; James et al., 2016). Similarly, wearable devices that measure heart rate variability can also now be used to indicate cardiovascular fitness and stress levels (de Brito et al.2020). A range of other exposome data, from particle pollution (e.g. particulate matter (PM) down to 2.5 micrometer diameter), much of which may be anthropogenic (Golicha Wako, 2025), to sometimes finer levels of fungal, plant, bacterial and viral particles and chemical compounds can also now be captured via wearable devices (Jiang et al., 2018). Exposure to sunlight via UV detectors, exposure to airborne gases (Lin et al, 2022) and exposure to sound (volume and pitch) can also be measured via wearable technology (Margaritis et al., 2018; Fischer et al., 2022). Goodchild (2007) has coined the term volunteered geographical information (VGI) to describe the creation of data by citizen scientists and volunteers (crowd sourcing) often using mobile technologies and sensor devices (Matthews & Yang, 2013). VGI is clearly a valuable approach that is likely to be used widely in future environment and health research and offers previously unattainable amounts of individual-level data to be collected. However, as with any methodology, it comes with its own limitations, some of which are to do with the volume and variety of data collected (about which more, below) but also to do with potential bias in samples and whether VGI affects citizen behaviour. The potential bias is true of many methods to obtain self-report data from participants who have to agree to undertake a range of tasks but, because of the participant burden in terms of wearing devices (which may need to be regularly charged and have their data uploaded) it seems that VGI is likely to attract only enthusiasts for the research topic who have time and energy to take on additional daily commitments. This may result in comparatively little data from people who are struggling financially, working long hours and with little flexibility in schedules or demands on their time and resources. Yet such people may be those whose exposome we most want to research, especially in trying to understand health inequalities. The danger of VGI methods altering participants' behaviour in ways that reflect a desire to please the researchers or satisfy self-belief, i.e. confirmation bias, is perhaps less problematic but important to recognise. The use of wearable or hand-held devices to promote behaviour change towards healthier behaviours (e.g. using pedometers to promote more physical activity, Baker et al., 2008) is also prevalent, however, and needs to be taken into account in designing and reporting on research (e.g. Nioi et al., 2020).

Whether or not wearable devices are used to collect environmental data to research aspects of the exposome, interest in microscopic airborne and waterborne particles is growing as understanding of their importance to health is expanding (Zerbo et al., 2021; Anguita-Ruiz et al., 2023). The levels of pollutants in many urban areas arising from vehicular traffic and use of carbon-based fuel for engines, heating and cooking are causing concern as evidence of their detrimental effects and penetration into human metabolic systems grows (Dyer, 2020). There is similar concern over microplastics and other anthropogenic chemicals and organic compounds (e.g. from agricultural use of hormones, pesticides; foul drainage from urban areas, etc.) prevalent in water, whether we are exposed to these when engaged in water sports etc., and accidentally imbibe them directly, or whether we ingest them, via the food chain, in what we eat and drink (Jarvie et al., 2025; Tanentzap & Fonvielle, 2024). If researchers are interested in understanding salutogenic landscapes and other healthy places, then we also need to know how such environments ameliorate or add to these potentially hazardous exposures. This will be a vital area to research further in future.

Equally important are the beneficial aspects of exposure to the natural environment, such as the turpenes that woodlands release into the air and other biological compounds that we are exposed to when we walk through a vegetated area or disturb the soil: the microbiome. The relationships between external and internal microbiomes and the benefit that plants and fungi, in particular, offer human health are important in elucidating the mechanisms by which exposure to natural environments may enhance our wellbeing. What we breathe and ingest as we take a walk in the woods may support our health in ways we have only recently become aware of, despite such healthy outcomes being perhaps taken for granted in folk wisdom as well as recent, more empirical, evidence. Some turpenes act as natural antimicrobials and evidence shows that such phytoncides can support human health as well (Tsunetsugu et al., 2010; Levy et al. 2025). Recent research on the microbial gut-brain axis (Lou et al., 2023), shows that psychological stress can affect internal microbiota through the gut-brain pathway, and conversely, gut microbiota can be enhanced by exposure to the natural environment, which can alleviate psychological stress-induced symptoms. The researchers show that neurotransmitter, endocrine, and immune pathways are implicated and there is clearly more work to be done to explore such pathways and their associated mechanisms.

As I mentioned above, in all such research on salutogenic environments, measuring spatiotemporal variables at appropriate scale and granularity is a challenge. What is the relevant timescale over which to understand the influence of environment on health? Much of our work in OPENspace over the past 20 years has engaged with older people and their wellbeing. This reveals just how important the lifecourse of place (Pearce et al., 2016) concept is in understanding how people may (or may not) flourish in older age. It is clear that childhood and early years exposure to salutogenic landscapes can enhance health - cognitive, mental and physical - for the rest of a person's life, such is the importance of these early developmental stages (Pierau et al., 2021). Equally, there may be benefits and effects that accumulate due to repeated exposure to salutogenic environments throughout life, and as we approach older age, we may also become more sensitive to certain environmental exposures, for good or ill, that would not have affected us so much at an earlier age (Cherrie et al., 2018; 2019). I am grateful to health geography and psychology colleagues, with whom we in OPENspace have collaborated over decades, for important insights into such research and there is much still to learn from taking such an approach.

As the above examples show, multi- and inter-disciplinarity research is key to future innovation in understanding healthy space. There are many disciplines that have something to offer and I have only mentioned a few of the areas of expertise that maybe relevant. We need to work with experts in environmental psychology, geography, epidemiology, neuroscience, sociology, microbiology, gerontology and geriatrics, psychophysiology and psychoneuronendocrinology, to mention but a few. But working across disciplines brings complexity and many challenges in how to collect, store and analyse data in appropriate ways, as well as how to interpret results meaningfully. Data protection legislation requires researchers to carefully protect individuals' data, as we should, and that can involve layers of approval and restrictions on access to data that can add considerably to the time needed to access and analyse results. Equally, there is a challenge in working out what to focus on and what might be most useful for policy-makers and planners. If we research the psycho-social as well as physical environmental exposure and influences (e.g. parental behaviour) on the exposome in depth, we inevitably end up with a conclusion that everyone is different from everyone else and each person's experience and exposure is unique. While this is true, it is not helpful for those who want to develop policies to enhance health effectively and efficiently for those that need it most. It is also increasingly possible to gather vast amounts of data via digital methods and to use complex, sometimes machine-learning-based analysis tools to investigate the data. However, unless the right questions are asked, this can lead to time- and resource-intensive analyses that produce results which are not meaningful or useful in practice. In addition, often leads to a great volume of data being collected and stored but not adequately investigated or requiring very sophisticated statistical techniques to do them justice. For example, in considering the exposome, Anguita-Ruiz et al., (2023) raise issues of high dimensionality and multicollinearity in looking at exposome, especially in relation to multi-morbidity (more than one health outcome). Thus, running across all these burgeoning areas for new research is a need for studies to focus on what is salient, most useful, and to use only those measures which are important for the research question in hand. Logic Models and Theories of Change are useful tools in assisting with this. Ultimately what is most needed (and will be increasingly so) is parsimony of research design – the fewest variables explored to produce the most robust and meaningful findings.

In OPENspace research centre, we have focused on what is important for landscape architects and other planners, designers and managers of the physical environment. This is based on recognising, in particular, that we can change the publicly accessible environment in ways that can potentially affect everyone who enters that environment, thereby having a population-wide effect that may be salutogenic. Recent exposome research supports this: “Overall, our results indicate that environment-focused interventions are likely to have the highest impact on ameliorating premature mortality and most age-related morbidity.” (Argentieri et al 2023). Our work has also acknowledged the great complexity involved in trying to understand how the physical environment influences health and suggests it is probably best not to use the more clinical epidemiological language of ‘environmental determinants of health’ or ‘disease’ but rather to describe our work as investigating contributors to, or influences on, disease or health. Nonetheless, there are many useful ways we can contribute to policy and practice in future as we work to understand salutogenic environments better.

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