A rapid scoping review of health and wellbeing evidence for the Framework of Green Infrastructure Standards

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Background

Natural England commissioned this report to inform the development of the National Framework of Green Infrastructure Standards, a commitment in the Government's 25 Year Environment Plan, which Natural England is leading to green our towns and cities for health and wellbeing, nature, climate resilience and prosperity, in particular for disadvantaged urban populations.

Natural England commissions a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties.

The views in this report are those of the authors and do not necessarily represent those of Natural England.

Natural England is delivering this commitment with funding and support from the Department for Environment, Food, and Rural Affairs, Public Health England and the Ministry of Housing, Communities and Local Government.

Natural England and Public Health England have collaborated on this publication.

Foreword

A surge in people visiting parks, beaches and nature reserves during the past few months of the coronavirus (Covid 19) pandemic has underlined the importance of green infrastructure[1] for health and wellbeing. Our People and Nature survey showed that in May, during lockdown, eight out of 10 adults agreed that "being in nature makes me very happy". In addition, 41 per cent reported that visiting local green and natural spaces had been even more important to their wellbeing.

These green spaces have played a vital role in offering people under lockdown opportunities for exercise, fresh air, contact with nature, and play and relaxation. They have been especially important for people living in the one in eight homes that do not have a garden. Covid 19 has also highlighted the inequalities that exist in people's access to private gardens and to parks and green spaces.

This review of evidence for the health and wellbeing benefits of green infrastructure sets out the sizeable body of research that underlines the importance of creating more, bigger, better and joined-up green spaces, especially near to where people live, and to address inequalities. It also identifies the beneficial role of social interventions such as media campaigns to increase awareness of green spaces, or holding community events in a natural environment. Finally, it reviews the wider health and wellbeing role of green infrastructure, for example in nature recovery, addressing climate change and mitigating noise and air pollution.

This evidence review was achieved through collaborating with experts across public bodies to drive policies for public health benefits. It will inform the emerging Framework of Green Infrastructure Standards being led by Natural England, which aims to help stakeholders enhance the nation's green infrastructure provision so that it can play a vital role in the nation's green recovery from Covid-19. Nature needs to move to front and centre in how we plan for the future of our country at this pivotal moment.

Tony Juniper

Chair, Natural England

[1] Green infrastructure is a network of multi-functional green space, urban and rural, which is capable of delivering a wide range of environmental and quality of life benefits for local communities (HM Government, 2019). It includes green space which is any vegetated land or water within an urban or built up area this includes parks, public gardens, playing fields, sports areas, play spaces, allotments and community gardens

A rapid scoping review of health and wellbeing evidence for the Green Infrastructure Standards

For
Natural England, Department for the Environment, Food and Rural Affairs, Public Health England, and Ministry for Housing, Communities and Local Government

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Further information
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Preface

This Evidence Review of the health and wellbeing benefits of green infrastructure, was undertaken in 2019 before the Covid-19 pandemic. Surveys during this pandemic highlighted the value that people placed on access to greenspaces and private gardens in coping with the challenges of the pandemic and the 'stay at home' measures to control its spread. For example, the People and Nature Survey for England found that, in May 2020, the vast majority of adults (89%) agreed or strongly agreed that green and natural spaces should be good places for mental health and wellbeing, with 30% reporting visiting *local* green and natural spaces more than usual (Natural England, 2020).

People's response to these measures also led to greater awareness of the inequalities in access to publicly available greenspace and private gardens amongst different socio-economic and demographics groups, for example 1 in 8 households do not have a garden (Office of National Statistics, 2020). This highlighted the importance of public greenspace provision for contact with nature.

Natural England intends to update this review to reflect the new evidence arising from Covid-19 regarding the use of and value of greenspaces and wider GI for health and wellbeing benefits, drawing from surveys and research undertaken into people's use of greenspaces during 'lockdown' and the subsequent easing and recovery period, including Natural England's People and Nature Survey (https://www.gov.uk/government/collections/people-and-nature-survey-for-england).

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Executive summary

Background

This rapid scoping review of evidence relating to the links between green infrastructure and health and wellbeing was produced to support the Natural England, Department for the Environment, Food and Rural Affairs (Defra), Public Health England (PHE) and Ministry for Housing, Communities and Local Government (MHCLG) funded development of a *Framework of Green Infrastructure Standards for England*, one of the commitments of the Government's 25 Year Environment Plan (HM Government, 2018). This summary review contributes to the *Green Infrastructure Standards for England Technical Summary Report and Evidence Review* (unpublished) led by LDA Design. The review is aimed primarily at governmental (national and local) departments with responsibility for, or an interest in, how green infrastructure relates to health and wellbeing of the population of the UK.

The review assess evidence relating to the (1) Health and wellbeing outcomes of exposure to green infrastructure; (2) Active pathways between green infrastructure exposure and health and wellbeing outcomes; (3) Passive pathways between green infrastructure exposure and health and wellbeing outcomes; (4) Ecosystem disservices and health; (5) The type, amount, proximity, and quality of green infrastructure and health outcomes; (6) Promoting and protecting health with green infrastructure interventions; and (7) Promoting pupil mental health, wellbeing and educational outcomes with green infrastructure.

Method

A systematised rapid scoping review was used to identify key empirical evidence relating to the broad health and wellbeing topics as requested for the Green Infrastructure standards development. Evidence of relevance to the UK context was sought and empirical systematic reviews, meta-analyses and robust primary evidence were prioritised. The review and non-systematic assessment of the extent and certainty of the evidence base seeks to present a fair interpretation however it must be noted that due to the resources available to complete the work the review is not fully systematic, is not exhaustive, and the quality of the evidence was not assessed.

Review findings

Linkages between green infrastructure and health

- The evidence base indicates that green infrastructure has a positive influence on population and individual level health and wellbeing. There is established, but variable or incomplete, evidence which indicates that more frequent exposure to green infrastructure has a positive influence on mortality rates, certain types of morbidity, mental health, quality of life, and is associated with less stark inequalities in health.
- There is some un-certainty as to how green infrastructure benefits health and wellbeing. It is likely that green infrastructure influences health and wellbeing through direct and 'active' pathways such as promoting positive mental health states, providing a context and motivation for physical activity and recreation, and allowing people to experience nature. However, the evidence base is incomplete and sometimes inconsistent. It is also likely that green infrastructure influences health and wellbeing through indirect or 'passive' pathways such as contributing to healthy micro-biomes and better nutrition, and through the mitigation of health risks such as heat island effects, noise pollution, flooding and poor air quality. Health and wellbeing outcomes of exposure to green infrastructure

through both direct/active or indirect/passive pathways are highly context dependant. Whilst these pathways are likely, the evidence base is limited, and in some cases incomplete and inconsistent.

- There is established but incomplete evidence which suggests that green infrastructure can result in ecosystem dis-benefits such as increased exposure to pollen or zoonotic disease which have the potential to harm health and wellbeing.

Who benefits from green infrastructure and in what ways?

- All social groups are likely to benefit from exposure to and/or use of green infrastructure however the evidence is currently inconsistent on who benefits, in what ways, and to what degree. Some groups, including more socio-economically deprived and disadvantaged populations, appear to disproportionately benefit from greener living environments. The evidence base suggests that there is no consistent pattern in the distribution of green infrastructure according to socio-demographics; in some areas more socio-economically deprived and disadvantaged groups have similar provision of green infrastructure to less socio-economically deprived and disadvantaged groups, in other areas there are inequalities in provision. There is some evidence to suggest that green infrastructure tends to be poorer quality in more socio-economically deprived and disadvantaged areas.

What is 'good' or 'good enough' green infrastructure for health and wellbeing outcomes?

- Currently the evidence base has limited utility for clarifying what is 'good' or 'good enough' green infrastructure. Whilst it is likely that the type, amount, location/proximity, and quality of green infrastructure are key factors in health and wellbeing outcomes the evidence is, as of yet, incomplete, variable and in some cases inconsistent. However, the evidence indicates that:
    - Greener living environments are associated with better health and wellbeing.
    - Different types, sizes and configurations of green infrastructure afford different benefits and that mixed provision (e.g. a mix of publicly accessible greenspaces, domestic and shared gardens, green routes and street trees) is most likely to be beneficial. Both publicly accessible and private greenspace (e.g. domestic gardens, institutional spaces) have a role in promoting health and wellbeing.
    - It is likely that greenspaces that are closer to the home or education/work place are important, however 'accessibility' varies according to factors such as urban form, terrain, climate, availability of transport, and to personal factors such as preferences, physical capacity to walk etc. It also appears that people are selective in their choice of destination and that proximity is not necessarily the primary factor. The *perception* of proximity appears to be as important as *objective* proximity.
    - Better quality and well-maintained green infrastructure is associated with better health and wellbeing outcomes. The *perception* of quality, which is highly variable between socio-cultural groups, is again important.
    - The evidence suggests that the value of different types, amounts and locations of green infrastructure for health and wellbeing outcomes is likely to be highly contextual; what is appropriate in one locale may not be appropriate in another.

Does improving the amount, quality and connectivity of green infrastructure improve health and wellbeing?

- Currently the evidence base has limited utility (there are a very small number of robust studies and demonstrating health or wellbeing gain resulting from environmental change is complex) for clarifying how the provision of new green infrastructure, or the

modification and adaptation of, or changes to the management or promotion of existing green infrastructure, could be used to improve health and wellbeing. However, the evidence indicates that:

- In new developments mixed provision (e.g. a mix of different sizes and types of publicly accessible greenspaces, domestic and shared gardens, green routes, street trees etc.) with appropriate connectivity is most likely to be beneficial.
- Improving the quality and management of green infrastructure and improving knowledge of and accessibility of spaces may have a positive impact on perceptions and use. Interventions to promote use likely need to be plural, involving changes to physical spaces in addition to complementary social programmes.
- There is evidence that new, or modifications to the provision or management of existing green infrastructure can exacerbate inequalities in health through processes such as gentrification or unequal access.
- The provision, modification or use of green infrastructure to promote health and wellbeing is most likely to be successful if there is a good understanding of the local social, cultural and economic context, where the health needs of target populations are understood, and where linkages are made with, and buy-in gained from wider networks of social and health services. Further effective approaches are informed by a theoretical understanding of the ways in which the environmental change may influence health and where the desires and perceptions of local communities are taken into account.

Is there a set of suitable metrics for assessing or monitoring the health benefits of green infrastructure?

As of yet there does not appear to be an applicable set of robust health and wellbeing metrics ready to be tested. A process of synthesis and prioritisation and then testing and refinement is needed to identify sets of need/provision and impact/outcome metrics for the key benefit categories at different spatial scales and in different contexts.

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Key terminology

Health	Health is a complex adaptive system relating to the resilience and capacity to self-manage in the face of social, physical, emotional and environmental challenges, a dynamic state, one that is not fixed nor absolute, and one that is constantly responding to environmental, social, biological, emotional and cognitive conditions or states (Lovell, 2018).
Wellbeing	Individual wellbeing is 'an overall evaluation that an individual makes of his or her life in all its important aspects' (Diener, 2009) and as a 'state of equilibrium or balance that can be affected by life events or challenges' (Dodge et al., 2012).
Quality of life	Quality of life is the influence of all aspects of an individual's life, which can include their health, on how they feel.
Green infrastructure	A network of multi-functional green space, urban and rural, which is capable of delivering a wide range of environmental and quality of life benefits for local communities (HM Government, 2019).
Greenspace	Greenspace is any vegetated land or water within an urban or built up area this includes parks, public gardens, playing fields, sports areas, play spaces, allotments and community gardens[2].
Ecosystem services	Ecosystem Services are the components of nature that are directly and indirectly enjoyed, consumed, or used in order to maintain or enhance human well-being.

Abbreviations

Defra	Department for the Environment, Food and Rural Affairs
GI	Green infrastructure

[2] Greenspace Scotland and OS Greenspace map definition

Key messages

Green infrastructure is the network of green and blue spaces and features in both urban and rural places. It can include wildlife areas and woodlands; road verges and rights of way; parks and gardens; canals, rivers and wetlands; green-grey infrastructure such as green bridges and green walls or roofs; and natural flood management and sustainable drainage. Green infrastructure is a vital element of healthy places.

The evidence suggests that people who live in neighbourhoods with greater amounts of green infrastructure tend to be happier, healthier and live longer lives than those who live in less green places. It is likely that everybody benefits from green infrastructure. However, it may be that more disadvantaged communities benefit to a greater degree.

Although understanding is still limited, studies have shown that green infrastructure supports health and wellbeing through promoting positive mental health states, providing a context and motivation for physical activity and recreation, and allowing people to experience nature. Green infrastructure may also benefit health and wellbeing through contributing to healthy micro-biomes and better nutrition, and through reducing heat island effects, noise pollution, flooding, and poor air quality.

There are potential risks from the presence of green infrastructure. These include increased exposure to pollen or to disease vectors such as ticks.

There is still a need for further research to understand what types or amounts of green infrastructure are most beneficial for the health of different communities. Further evidence is also needed to identify the most effective ways of providing new or improved green infrastructure to promote health. Despite this, the evidence does suggest a number of key principles:

- The provision of different types of green infrastructure around the home, place of work or education, or along transportation routes, is likely to maximise the potential ways in which people benefit.
- Both public (such as street trees, parks, and playgrounds) and private (such as domestic gardens) green infrastructure are important and support health in different ways.
- Green infrastructure that is well looked after is more likely to be perceived as safe and inviting, and therefore to be used.
- A good understanding of the needs and desires of local communities will help ensure new or improved provision is suitable.
- New or improved provision of green infrastructure has the potential to increase inequalities in health between different social groups. This is complex but can come about through, for example, processes of social exclusion, gentrification and pushing up of house prices. Care must be taken to try and understand the potential impacts of actions and to ensure that provision is equitable and fair.

Background and introduction

This rapid scoping review of the evidence relating to the links between green infrastructure and health and wellbeing was produced to support the Natural England, Department for the Environment, Food and Rural Affairs (Defra), Public Health England (PHE) and Ministry for Housing, Communities and Local Government (MHCLG) funded development of a *Framework of Green Infrastructure Standards for England*, one of the commitments of the Government's 25 Year Environment Plan (HM Government, 2018). This summary review contributes to and forms a component of the *Green Infrastructure Standards for England Technical Summary Report and Evidence Review* led by LDA Design (unpublished)[3].

The document includes:

- A model of the pathways between green infrastructure and health and wellbeing.
- An assessment of the certainty of linkages between green infrastructure and health and wellbeing outcomes using the UK National Ecosystem Service framework (2011).
- Narrative summaries of the health and wellbeing benefits of Green Infrastructure.
- Conclusions and implications of the current evidence for green infrastructure planning, delivery and usage for health and wellbeing outcomes.
- A health and wellbeing evidence schedule with examples of key evidence.

The review is aimed primarily at governmental (national and local) departments with responsibility for, or an interest in, how green infrastructure relates to health and wellbeing of the population of the UK. It may also be of relevance to the many non-governmental organisations who are active in promoting or acting on the potential of green infrastructure to contribute to better health outcomes.

Method

A systematised rapid scoping review[4] was used to identify key empirical evidence relating to the broad health and wellbeing topics as requested for the Green Infrastructure standards development and in consultation with Natural England, Defra and the wider stakeholder group. This health and wellbeing summary review is an update of the Defra evidence statement published in 2017 (Maxwell and Lovell, 2017). Evidence of relevance to the UK context was sought and empirical systematic reviews, meta-analyses and robust primary evidence were prioritised. Narrative and literature reviews have been used where more systematic reviews are not available and primary studies have been included where they provide new evidence not covered in the reviews or to clarify points. Modelled data were not included.

Evidence was identified using key search terms in academic databases and by following citations. Search terms related to the environment and green infrastructure (e.g. greenspace, bluespace, parks, biodiversity, street trees, woodlands), to health and wellbeing (e.g. mortality, mental health, quality of life), for pathways and modifying factors (e.g. physical activity, inequalities, older people, children) and for study design (e.g. systematic review,

[3] https://www.lda-design.co.uk/

[4] See Grant, M. J., & Booth, A. (2009). A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Info Libr J, 26*(2), 91-108. doi: 10.1111/j.1471-1842.2009.00848.x for details of the review approach.

evidence synthesis). Relevant search terms were combined for each topic. Searches were conducted in key academic databases including PubMed, PsycINFO, Scopus, and Web of Science. Instead of one overall search, iterative and strategic searches were conducted for each benefit category, therefore a PRISMA chart is not available. More detail is provided in Appendix 1. The quality of the evidence included was not assessed and therefore is not considered in the interpretation.

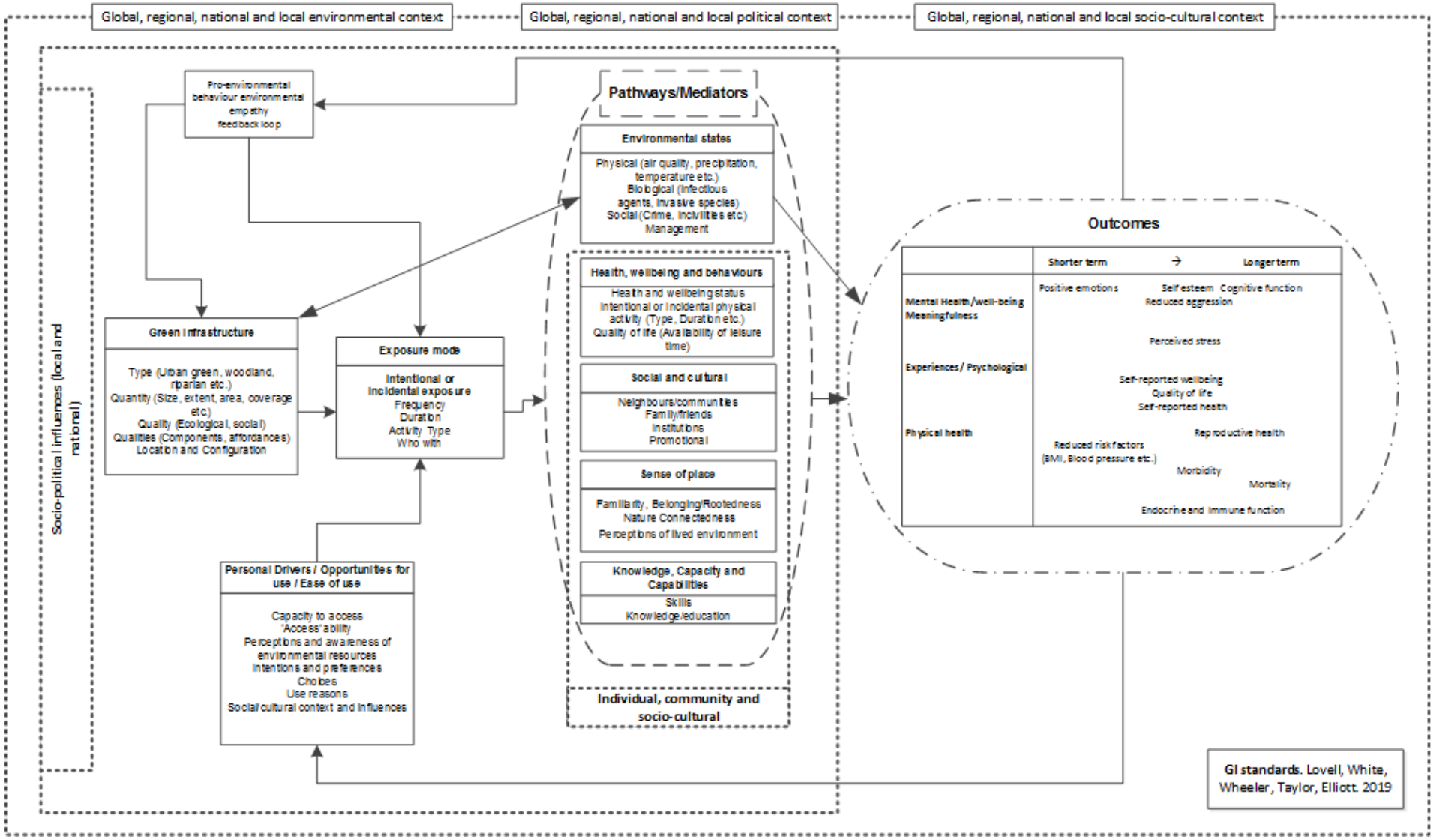
An annotated evidence schedule has been produced together with written narrative summaries for each broad topic. The narrative summaries provide brief overviews of the topic; highlighting what is known and commenting on the nature of the evidence base with an overview of strength/weakness and gaps. A non-systematic assessment of the extent and certainty of the evidence base was produced using the UK National Ecosystem Service Assessment methodology (UK National Ecosystem Assessment, 2011).

The review approach was informed by the methodologies as outlined in the Defra review guidance (Collins et al. 2015) and seeks to present a fair interpretation of the evidence base however it must be noted the review is not fully systematic; is not exhaustive and the quality of the evidence was not assessed. Causality of the effect of exposure on outcomes cannot be inferred except where it has been clearly identified in the reporting of the primary study or review.

The language of the original paper/study has been used throughout when referring to the environmental exposure (e.g. greenspace, park etc.) therefore there is some inconsistency of use. All reviews include evidence for countries other than the UK. The context of included primary studies is highlighted. It must, however, be noted that the transferability of evidence between contexts is not yet clear.

This review did not include evidence of green infrastructure effects on health risks such as poor air quality, heat islands etc. (see Passive pathways section) unless there was empirical evidence of observed impact to health outcomes.

Figure 1. Pathways between green infrastructure and health and wellbeing model



Certainty of linkages between green infrastructure and health and wellbeing outcomes

Table 1. Certainty of linkages between green infrastructure and health and wellbeing outcomes

See below table for key to assessment categories.

Benefit category	***Certainty***	***Likelihood***
1. Health and wellbeing outcomes of exposure to green infrastructure		
Reduced mortality	Established but incomplete evidence*	Very Likely
Reduced morbidity	Established but variable or incomplete evidence*	Likely
Better mental health	Established but variable or incomplete evidence*	Very Likely
Better quality of life	Established but variable or incomplete evidence*	Likely
Reduced health inequalities	Established but variable or incomplete evidence*	Likely
2. Active pathways between green infrastructure exposure and health and wellbeing outcomes		
Higher rates of physical activity	Competing explanations	Very Likely
Recreational benefits	Established but variable or incomplete evidence	Likely
Higher connection with nature and health/wellbeing outcomes	Competing explanations	Likely
Social contact and cohesion	Established but variable or incomplete evidence*	Likely
3. Passive pathways between green infrastructure exposure and health and wellbeing outcomes		
Healthy microbiome	Established but variable or incomplete evidence	Likely
Mitigation of or reduction of impact of heat island effects	Established but variable or incomplete evidence	Likely
Mitigation of or reduction of impact of noise pollution	Speculative	Likely
Mitigation or reduction of impact of flooding	Speculative	Likely
Mitigation of poor air quality	Established but variable or incomplete evidence	Likely
Improved nutrition	Speculative	About as likely as not

4. Ecosystem disservices and health		
Ecosystem disservices and health	Established but variable or incomplete evidence	Likely
5. The type, amount, proximity, and quality of green infrastructure and health outcomes		
Amount of GI on health and wellbeing	Established but variable or incomplete evidence	Likely
Location and proximity of GI on health and wellbeing	Speculative	Likely
Size of GI on health and wellbeing	Speculative	Likely
Type, features and characteristics of GI on health and wellbeing	Speculative	Likely
Quality of GI on health and wellbeing	Established but variable or incomplete evidence	Likely
Equity of availability of GI on health and wellbeing	Established but variable or incomplete evidence	Likely
6. Promoting and protecting health with green infrastructure interventions		
Physical (e.g. built, environment restoration etc.) interventions	Competing explanations	Likely
Social interventions and green prescriptions	Established but variable or incomplete evidence	Likely
7. Promoting pupil mental health, wellbeing and educational outcomes with green infrastructure		
Pupil mental health, wellbeing and psychological	Speculative*	About as likely as not
Scientific and educational outcomes	Speculative	About as likely as not
Attainment of skills and academic performance	Speculative	About as likely as not
Motivations to learn, enjoyment of learning and teaching	Speculative	About as likely as not
Improved concentration and behaviour	Speculative	About as likely as not
Opportunities or physical activity	Established but variable or incomplete evidence	Likely

* some or considerable variation in outcomes within category

Key to assessment terminology

Certainty

- Well established: high agreement based on significant evidence
- Established but variable or incomplete evidence: high agreement based on limited evidence
- Competing explanations: low agreement, albeit with significant evidence
- Speculative: low agreement based on limited evidence

Likelihood

- Virtually certain: >99% probability of occurrence
- Very likely: >90% probability
- Likely: >66% probability
- About as likely as not: >33–66% probability
- Unlikely: <33% probability
- Very unlikely: <10% probability
- Exceptionally unlikely: <1% probability

Method adapted from those used in the UK National Ecosystem Assessment (2011). Changes are in the *Certainty* assessment *Established but incomplete evidence: high agreement based on limited evidence* adapted to now state *Established but variable or incomplete evidence: high agreement based on limited evidence.*

Note: Whilst this assessment is based on the summary review of evidence, for which robust systematic reviews, meta-analyses and robust primary evidence were prioritised, it must be noted the review itself is not systematic or exhaustive and the quality of the evidence was not assessed.

Narrative summary of health and wellbeing benefits of Green Infrastructure

1. Health and wellbeing outcomes of exposure to green infrastructure

There is now a sizable body of evidence, summarised in a number of systematic reviews, which has demonstrated linkages between green infrastructure (including parks, street trees, incidental greenspace, bluespaces etc.) and multiple physical health, mental health and quality of life[5] outcomes in a range of different populations (see the Green infrastructure and health and wellbeing outcomes model) (Lovell et al., 2014, Gascon et al., 2015, Hunter et al., 2015, Lovell et al., 2015, van den Berg et al., 2015, de Keijzer et al., 2016, Gascon et al., 2016, Ohly et al., 2016a, Blaschke, 2017, Browning and Lee, 2017, Gascon et al., 2017, McCormick, 2017, van den Bosch and Ode Sang, 2017, Britton et al., 2018, Houlden et al., 2018, Kondo et al., 2018, Tillmann et al., 2018, Twohig-Bennett and Jones, 2018, Vanaken and Danckaerts, 2018, Browning and Rigolon, 2019, Lakhani et al., 2019). The majority of the evidence relates to adult health, with a smaller number of studies considering outcomes in children and young people. The linkages between green infrastructure and health and wellbeing outcomes are complex with indications of high levels of heterogeneity in the relationships according to a multitude of factors such as environmental, social and cultural context, the type, frequency and duration of exposure, and in relation to interactions with other health and wellbeing determinants.

The majority of the evidence is from cross-sectional studies, which can reveal associations between exposure and health states. The growing use of longitudinal and cohort data is helping unpick causal relationships between greenspace and health (McEachan et al., 2018, Cherrie et al., 2018, Bloemsma et al., 2018, Dadvand et al., 2017, Picavet et al., 2016, Dalton et al., 2016, McEachan et al., 2015, Annerstedt et al., 2012, Wolch et al., 2011, Alcock et al., 2015, Alcock et al., 2014).

Physical health and wellbeing

An extensive and robust systematic review and meta-analysis found that, whilst there is heterogeneity and limitations to the evidence base, the highest levels of exposure to greenspace (typically around the home residence) tends to be associated with more favourable salivary cortisol, heart rate, diastolic blood pressure, HDL cholesterol and pregnancy outcomes including pre-term birth and gestational age, and with significant reductions in the incidences of TII diabetes (Twohig-Bennett and Jones, 2018). Further reviews have also shown positive associations between greater exposure to greenspace and all-cause and cardiovascular mortality (Twohig-Bennett and Jones, 2018, Gascon et al., 2016, James et al., 2015) and self-assessed general health (van den Berg et al., 2015, Twohig-Bennett and Jones, 2018). Primary studies have shown that living in the greenest areas is associated lower risk of prostate cancer in a Canadian population (Demoury et al., 2017) and with respiratory and cancer mortality in women in an American population (James et al., 2016). A systematic review and meta-analysis showed that neighbourhood greenness for pregnant women is positively, but weakly, associated with the babies' birth weight (Dzhambov et al., 2014). Two primary studies from France and the US found associations between environmental conditions, including higher levels of greenspace, and reduced mortality in neonates and infants (Kihal-Talantikite et al., 2013, Lara-Valencia et al., 2012).

[5] See the Valuing Nature Programme's Demystifying health report for definitions of key health, wellbeing and quality of life terms. Lovell, R. (ed.) 2018. *Demystifying health* Wallingford Valuing Nature Programme.

Two systematic reviews found that exposure to greenspace is generally associated with more favourable body weight and obesity-related health indicators but that the evidence is mixed and inconsistent (Lachowycz and Jones, 2011, Gascon et al., 2017).

Reviews have shown that greenspace can play a role in helping people recover from illness, injury and poor health (Blaschke, 2017, Sonntag-Öström et al., 2015). A systematic review and meta-synthesis (of qualitative literature) found that experience of and use of the natural environment (through different modes and exposure routes) helped patients manage the clinical and personal consequences of cancer (Blaschke, 2017).

Reviews and studies from the UK and Western Europe have shown that disadvantaged groups and those living in the most socio-economically deprived areas appear to benefit to a greater degree than less disadvantaged and higher socio-economic groups (Twohig-Bennett and Jones, 2018, McEachan et al., 2015, Mitchell and Popham, 2008, Maas et al., 2006, Jennings et al., 2012). There is variation in impact according to other socio-demographic characteristics, however this differs between studies.

Mental health and wellbeing and cognitive function

Reviews have shown that greater exposure to greenspace (predominantly around the home) is generally associated with improved mental health and wellbeing in both adults (van den Berg et al., 2015, Gascon et al., 2015, Houlden et al., 2018, Gong et al., 2016) and children (McCormick, 2017, Tillmann et al., 2018, Vanaken and Danckaerts, 2018), and that living in the greenest areas is associated with more favourable cognitive development in children (McCormick, 2017). A systematic review found that exposure to bluespaces is associated with better mental health and wellbeing outcomes (Gascon et al., 2017).

A review found that greenspace exposure appeared to be linked to cognitive function in adulthood, however the evidence was assessed to be limited and of a poor quality (de Keijzer et al., 2016). Two primary studies using data from a Scottish longitudinal cohort found associations between greater exposures to greenspace in childhood and cognitive health and a slowing of the rate of aging in later adulthood (Cherrie et al., 2019, Cherrie et al., 2018).

Reviews have shown that exposure to greenspace can promote higher life satisfaction (Houlden et al., 2018), help aid psychological restoration (Ohly et al., 2016b), and mitigate the impact of stress (Kondo et al., 2018). However, most reviews caution that the evidence is currently limited and often inconsistent. Primary analysis of Dutch data found an association between greater amounts of greenspace in the living environment and reduced rates of suicide (Helbich et al., 2018) and with reduced rates of anti-depressant prescribing in the Netherlands (Helbich et al., 2018). Primary analysis of UK longitudinal data suggested that the mental health of people who moved to greener areas was significantly better than it was pre-move (Alcock et al., 2014).

Several reviews found evidence of positive associations between greater exposure to, or accessibility of greenspace and reduced rates of hyperactivity and inattention in children (Vanaken and Danckaerts, 2018, Tillmann et al., 2018, McCormick, 2017).

Systematic reviews have found that greater exposure to greenspace enhances quality of life for both children and adults through multiple social, economic, and environmental pathways (Tillmann et al., 2018, Mensah et al., 2016, MacMillan, 2013). Activities in natural environments, such as gardening, have been linked to higher quality of life (Whear et al., 2014). Primary research with children in the city of Edinburgh found significant positive associations between higher levels of greenspace use (though not higher quantity of available spaces) and improved quality of life scores (McCracken et al., 2016).

Mental health outcomes vary according to factors such as ethnicity and other socio-demographic variables. Reviews have shown that people from disadvantaged groups and living in the most socio-economically deprived areas appear to benefit to a greater degree than less disadvantaged groups (van den Berg et al., 2015, Gascon et al., 2015). Primary analysis of UK birth cohort data showed that ethnicity moderated relationships between residential greenspace and mental wellbeing (McEachan et al., 2018). A systematic review by Vanaken and Danckaerts (2018) found that the effects of greenspace on children and young people's mental health and wellbeing appears to vary according to developmental stage and in relation to the type and accessibility of greenspaces.

Inequalities in health and wellbeing impacts

As noted above, there is evidence from systematic reviews and primary studies that the health and wellbeing benefits of exposure to greenspace vary according to factors such as age, gender, ethnicity and other demographic factors, however consistent patterns have not yet been clarified and are likely to be highly context dependant (van den Berg et al., 2015, Richardson and Mitchell, 2010, Tillmann et al., 2018, McEachan et al., 2018, Kabisch et al., 2017, World Health Organisation, 2016, Wheeler et al., 2012, MacBride-Stewart et al., 2016).

Individual primary studies from the UK and Western Europe tend to find that accessible good quality natural environments appear to disproportionately benefit (especially in urban areas) the health and wellbeing of disadvantaged groups and that socio-economic related inequalities in health tend to be lower in greener communities (McEachan et al., 2015, Mitchell and Popham, 2008, Maas et al., 2006, de Vries et al., 2003, Wheeler et al., 2012, Mitchell et al., 2015). More even distribution of land uses, including greenspaces, has been linked to lower inequalities in life satisfaction (Olsen et al., 2019b). Further studies have shown that greenspaces can help promote resilience in vulnerable groups, for example women in low-income groups (UK) better cope with stress (McEachan et al., 2015).

2. Active pathways between green infrastructure exposure and health and wellbeing outcomes

There is currently little certainty as to the (causal) pathways linking urban greenspaces to health outcomes, however physical activity, provision of restorative spaces, contexts for social contact, and exposure to the natural world have been investigated (Hartig et al., 2014, van den Berg et al., 2015, Gascon et al., 2017, Gascon et al., 2015).

Physical activity

Several reviews have shown that although there is inconsistency there is some evidence which indicates that greenspaces and some other forms of green infrastructure, such as greenways, are associated with and support higher levels of physical activity (for leisure, active travel or for other purposes), the associations are stronger for some populations and vary according to context (Lachowycz and Jones, 2011, Lachowycz and Jones, 2014, Van Hecke et al., 2018).

Systematic reviews have found that the availability of natural spaces and attractive views of nature in the living environment is a determinant of physical activity behaviours, however there is variation in impact between socio-demographic group and between areas (Calogiuri and Chroni, 2014, O'Donoghue et al., 2016). There is some evidence from the UK and Western Europe which suggests that different types

of environments, for example bluespaces or sports fields, are more supportive of higher rates and intensity activity (Gascon et al., 2017, Van Hecke et al., 2018, White et al., 2016, Elliott et al., 2015, White et al., 2014). The evidence indicates that higher quality and better maintained spaces are more likely to be used (Lee and Maheswaran, 2010). There is mixed evidence on the role of the size of the space in supporting physical activity behaviours, with different sized and configured spaces supporting or facilitating different types and intensities of activity. However a number of studies have identified evidence that suggests that larger sized spaces may be more supportive of more intensive physical activity than smaller spaces even if further away (Schipperijn et al., 2010, Cohen et al., 2010, Sugiyama et al., 2010). Primary studies from the UK and Australia have shown that greenspaces are supportive of physical activity behaviours throughout the life course, from childhood to older age (Dalton et al., 2016, Wheeler et al., 2010, Bell et al., 2015).

Reviews have found some evidence that physical activity in green environments may be more beneficial to mental health outcomes than activity in other contexts (e.g. indoors) (Bowler, 2010, Thompson Coon et al., 2011). A primary study using Scottish data found that physical activity in natural environments was associated with a greater reduction in the risk of poor mental health than physical activity in other environments (Mitchell, 2013).

Recreation

Recreational visits to green or bluespaces may be one of the key routes through which the health impacts of green infrastructure arise. A number of systematic reviews have highlighted the role of natural environments in supporting and providing spaces for recreation (Joseph and Maddock, 2016, Hanson and Jones, 2015, Bancroft et al., 2015, Hartig et al., 2014, Calogiuri and Chroni, 2014). The most recent Monitor of Engagement with the Natural Environment survey revealed that three in five adults living in England (62%) reported taking visits to the natural environment at least once a week (Natural England, 2018). The proportion of people living in most deprived areas who had taken visits increased by 13 percentage points from 38% in 2009/10 to 51% in 2017/18. Eighteen percent visited less than once a month or never took visits. Younger people (age 16-24) were the most frequent visitors, compared to other age groups. People aged 65 and over, black, and minority ethnic groups and residents living in the most deprived areas of England were the least frequent visitors (Boyd et al., 2018). Just under half of visits were taken to natural places within a town or city while 39% were taken to the countryside and 12% to a beach or other coastal location, parks in towns and cities were the most popular destination type (Natural England, 2018).

Health and exercise is the main motivation for spending time in natural environments (Natural England, 2018). Thirty-eight percent of people ‘strongly agreed’ that spending time out of doors was an important part of their life (a further 49% ‘agreed’) (Natural England, 2018).

A systematic review found that different types of outdoor physical activities are associated with improved subjective wellbeing through improvements in self-competence learning and identity, a sense of escapism, relaxation and sensory experience, and improving social bonding as a family (Mansfield and et. al., 2018).

Connection with nature and wellbeing

A meta-analysis found that, whilst the effect was small, people who report they are more 'connected to nature' tend to experience more positive affect, vitality, and life satisfaction compared to those who judge themselves less connected to nature (Capaldi et al., 2014). A further meta-analysis found positive associations between nature connectedness and evaluative wellbeing, particularly 'personal growth' (Pritchard et al., 2019). However, the direction of effect is not clear. Primary analysis of data from England found an association between different types of environment and connectedness to nature; with urban greenspaces and coastal areas with designated status more likely to be associated with greater connectedness to nature than locations without designated status (Wyles et al., 2019).

Social contact and cohesion

There is a small body of evidence which has sought to clarify if and how greenspaces benefit health through social pathways (Hartig et al., 2014). A review found some evidence to suggest that greenspaces enable social contact, reducing isolation, and are associated with perceptions of greater social cohesion (Hartig et al., 2014). Analysis of Dutch data found that lower percentages of green space in the living environment was associated with higher likelihood of people reporting feeling of lonely and that they had a perceived shortage of social support (Maas et al., 2009). However, the effects of greenspaces on health are moderated by feelings of safety and the behaviours of other users (Van Hecke et al., 2018, Weimann et al., 2017).

3. Passive pathways between green infrastructure exposure and health and wellbeing outcomes

Further factors that may explain health and wellbeing benefits include mitigation or avoidance of the effects of urban heat islands, air and noise pollution, flooding, as well as greater opportunities to benefit from the micro-biome and access to nutrients. Whilst the use of green infrastructure to mitigate the health impacts of poor air quality, extreme weather events and so on is highly plausible there appears to be little direct empirical evidence available.

The microbiome

Literature review and commentary papers suggests that exposure to biodiverse environments is associated with the more positive immunoregulatory health through internal micro-biome pathways (Rook, 2013, Flies et al., 2018, Flies et al., 2017, Hough, 2014, Mhuireach et al.). These studies suggest that macro-biodiversity (e.g. plants and trees) in urban environments is associated with environmental microbe diversity and in turn with a healthy human microbiome, known to be linked to a wide range of health outcomes. However, there are few studies empirically testing this pathway. One recent exploratory study used post-mortem human microbiome assessments (n=48) and data on 'green remediation' in Detroit, USA, and found suggestions of a 'healthier' microbiome amongst individuals residing in locations with green infrastructure interventions (Pearson et al., 2019). Another study in Finland indicated that individuals with atopic conditions (allergies) lived in areas with lower surrounding biodiversity, and had lower skin microbe diversity, compared to those without atopy (Hanski et al., 2012).

Heat island

A systematic literature review found that natural environments in urban areas is positively associated with heat reduction, with a potential mediating effect of urban natural environments on reduced cardio-vascular disease related mortality (van den Bosch and Ode Sang, 2017). A review of 89 studies of green infrastructure impacts on heat mitigation indicated a 'park cool island' effect of between 1.5-3.5°C, with no difference between interventions in different climatic regions (Saaroni et al., 2018). The review also indicated a stronger cooling effect of larger urban green spaces, and an important role for street trees in cooling and heat relief. Another review of trends and gaps in the evidence on green infrastructure and urban heat found that most studies focus on micro-scale impacts, and there is limited knowledge of broader temperature impacts, for example of green infrastructure connectivity at city scale (Bartesaghi-Koc et al., 2019).

Noise pollution

A systematic review found moderate evidence that presence of vegetation can reduce the negative perception of noise pollution in urban areas (Dzhambov et al., 2018). Primary analysis of Spanish data found that noise mediated the associations between exposure to greenspace and mental health outcomes (Gascon et al., 2018). A Swedish study suggested that greenspaces provide an escape from noise pollution and greater availability is associated with reduced prevalence of stress-related psychosocial symptoms (Gidlof-Gunnarsson and Ohrstrom, 2007).

Flooding

A systematic review found only limited evidence, in the small number of studies available, that rain gardens, bio-swales, green roofs, and biodiverse plantings have a positive impact to health through several pathways (Suppakittpaisarn et al., 2017). However, more general evidence exists suggesting that 'green building methods' can be important components of catchment-wide flood management and may reduce flood-related risks of waterborne disease, morbidity and mortality, and psychological harm (Houghton and Castillo-Salgado, 2017). A Southampton-based case study found potential value in mapping surface infiltration capacity and leaf coverage in assessing flood control and urban cooling potential (Farrugia et al., 2013).

Air quality

While some studies indicate a role for green infrastructure in air quality improvement (e.g. Nowak et al. (2014)), several literature reviews have concluded there is little evidence demonstrating if or how urban green infrastructure mitigates or exacerbates the health and wellbeing impacts of poor air quality (Salmond et al., 2016, Escobedo et al., 2011). One recent review has indicated the need for a nuanced understanding and approach, with vegetation potentially exacerbating or improving air pollution health impacts dependent on the exact nature of the vegetation and the surrounding urban morphology (e.g. canyons versus open streets (Abhijith et al., 2017)). One very focussed study in Spain based on personal monitoring indicated that pregnant women living in greener areas were exposed to lower levels of air pollution, suggesting this could be one pathway explaining findings of improved birth outcomes for women living in greener areas (Dadvand et al., 2012). Analysis of US mortality data by James et al. (2016) indicated that the association between green infrastructure and mortality was partly mediated by particulate matter < 2.5 μm, in addition to other factors including physical activity, social engagement, and depression. Analysis of Canadian data found associations between particulate matter < 2.5 μm and mortality decreased as greenness in the living environment increased (Crouse et al., 2019).

A primary study from the UK indicated there are interactions between the amount and type of green infrastructure and pollution levels on health outcomes (Alcock et al., 2017). Alcock et al. (2017) found reductions in asthma hospitalisation were associated with presence of greenspace and gardens when pollutant exposures were lower but no significant association when pollutant exposures were higher. Tree density was also found to be associated with reduced asthma hospitalisation when pollutant exposures were higher but not when pollutant exposures were lower (Alcock et al., 2017). A primary study using US data found higher particulate matter-hospitalization for cardiovascular and respiratory diseases in areas with less greenspace (Heo and Bell, 2019).

Nutrition

A literature review found that urban edible green infrastructure (including some forms of urban and peri-urban agriculture) contribute to sustainability and food security but are also linked to health disbenefits such as exposure to heavy metals and organic chemical contaminants, however much of the available evidence relates to developing counties and may not be applicable to the UK context (Russo et al., 2017).

4. Ecosystem disservices and health

Several literature reviews have found some evidence of urban ecosystem and green infrastructure disbenefits to health through pathways such as increased allergenic compounds, vector-spread and zoonotic disease, increased feelings of anxiety and reduced quality of life through animal and plant litter, and through feelings of insecurity and fear caused by dense urban greenspaces (von Döhren and Haase, 2015, Lõhmus and Balbus, 2015). A literature review carried out for the World Health Organisation identified further evidence of potential harm to health associated with green infrastructure (World Health Organisation, 2016). Increased outdoor use of greenspaces can increase exposure to poor air quality and, as noted above, the morphology of the urban landscape and types of vegetation can exacerbate exposures to and impacts of air pollutants (World Health Organisation, 2016, Abhijith et al., 2017). Green infrastructure management practices may increase exposure of populations to pesticides, herbicides and fungicides (World Health Organisation, 2016). Green infrastructure may also be associated with enhanced risk of accidental injury (World Health Organisation, 2016).

5. The type, amount, proximity, and quality of green infrastructure and health outcomes

There is currently insufficient evidence to draw confident conclusions regarding the most appropriate type, amount, proximity, and quality of green infrastructure to bring about positive impacts to health and wellbeing. However, the existing evidence base does provide some indications which have led to several recommendations for accessibility indicators for health outcomes. A robust example is that proposed by Annerstedt et al (2015) of a 300 m maximum linear distance to the boundary of urban green spaces of a minimum size of 1 hectare. A similar approach was proposed following a review of the evidence by the World Health Organisation (2016).

Amount

The majority of the available evidence linking greenspace to health outcomes considers relationships at a local area level, typically the amount of greenspace around the home (Houlden et al., 2018). Reviews have suggested that cumulative exposure to greenspace

appears to be most strongly associated with health outcomes (Dinand Ekkel and de Vries, 2017, Houlden et al., 2018). A review found that the evidence linking the total amount of greenspace in the living environment with mental health outcomes is stronger than for visits to greenspace (Helbich et al., 2018), although this may be driven by the relatively large numbers of studies investigating greenspace availability versus those investigating visits (Houlden et al., 2018).

There is uncertainty regarding the extent of what should be considered as the home 'neighbourhood'. A review of 47 studies found that considering all greenspaces in a 2000m buffer around the home was most strongly associated with health outcomes in comparison to only focusing on more local greenspaces (Browning and Lee, 2017). Other studies have found that green resources closer to the home are more strongly associated with health, for instance a systematic review and meta-analysis showed that neighbourhood greenness for pregnant women within a 100-m buffer is positively, but weakly, associated with the babies' birth weight (Dzhambov et al., 2014). It is likely that there are different levels of exposure necessary to bring about different health outcomes and that the relative important of amount varies according to the type and spatial mix of green infrastructure.

The amount of greenspace and green infrastructure around work and leisure environment, and along travel or commuting routes, have additional impacts on health but they are not well understood (Colley et al., 2016).

Location

As of yet the evidence base is inconclusive as to the most appropriate siting of urban green infrastructure for maximum and equitable health benefit (Wolch et al., 2014, Haase et al., 2017, Kessel et al., 2009, Bancroft et al., 2015). Analysis of greenspace usage data from Bristol, UK, found that people living closer to greenspaces of at least 2 hectares were more likely to meet the recommended levels of physical activity than people living further away (Coombes et al., 2010). However there is evidence from several UK studies that people travel to specific amenities outside their home neighbourhood, even if other similar alternatives are also available close to home (Olsen et al., 2019a, Hillsdon et al., 2015). One primary study found that over 60% of outdoor low-moderate physical activity occurred outside the home neighbourhood or over 800m from the home (Hillsdon et al., 2015). This suggests that provision may need to be considered within a wider context.

There appear to be stronger associations between proximity, particularly to good quality greenspaces around the residence, and health outcomes for lower socio-economic groups (Wheeler, 2012, O'Brien, 2006, Mitchell and Popham, 2008). Good *perceived* access to greenspace has been shown to be associated with more reduced inequalities in mental health outcomes (Mitchell et al., 2015).

Other forms of green infrastructure, such as that along commuting routes, have been linked to health and behavioural outcomes (Säumel et al., 2016, O'Donoghue et al., 2016). A systematic review and meta-analysis found that more 'walkable' neighbourhoods and places with greater amounts of greenspace were linked to lower risk or prevalence of diabetes type II (den Braver et al., 2018). However interactions between the presence of greenspaces and factors such crime and urban form, as well as age or gender, affect the likelihood of spaces being used (Richardson et al., 2017).

Size

There is uncertainty regarding the necessary size of greenspaces for beneficial health and wellbeing outcomes. The systematic review undertaken by Gascon et al. (2016) found no

evidence which clarified the necessary size (or proximity) of greenspaces for reduced mortality.

There is some evidence from individual primary studies, predominantly from Western Europe and Australia, that larger sized parks and greenspaces are more supportive of higher intensity physical activity and some health outcomes than smaller spaces even if those larger spaces are further away, however the evidence is not yet conclusive (Schipperijn et al., 2010, Rundle et al., 2013, Cohen et al., 2010, Sugiyama et al., 2010).

Primary Dutch research found that larger sized greenspaces (≥7 ha) were associated with higher levels of physical activities including walking, jogging and cycling (Jansen et al., 2017). However, the creation of new Pocket Parks (US) was shown to have resulted in increased population levels physical activity and compared favourably in promoting moderate-to-vigorous physical activity to existing nearby parks (Cohen et al., 2014).

Type, features and characteristics

Individual studies indicate that different types of environments appear to afford, or be supportive of different types of health outcomes or physical activities in different populations, however there does not yet appear to be any systematic examination of the relative health values of different environment types (Jansen et al., 2017, Van den Berg et al., 2014, Bancroft et al., 2015).
Some studies from the UK, Western Europe and the US have indicated that health, wellbeing and behavioural outcomes vary as a result of exposure to or availability of different types of vegetation, green or blue spaces, and green infrastructure (Reid et al., 2017, Wheeler et al., 2015, Elliott et al., 2015, Jansen et al., 2017, Alcock et al., 2015, White et al., 2013, Marselle et al., 2013, Marselle et al., 2015) others have found little or no variation (Richardson et al., 2018, Van den Berg et al., 2014).

The majority of the available evidence relates to urban greenspaces (such as parks) (Cherrie et al., 2019, Harris et al., 2017, Dallimer et al., 2014), woodlands (Ward Thompson et al., 2019, Ward Thompson et al., 2013, O'Brien and Morris, 2013, Morris and O'Brien, 2011), and in relation to blue spaces (Völker and Kistemann, 2011, Gascon et al., 2017, Gascon et al., 2015). There is less evidence on other forms of green infrastructure such as street trees (Lovasi et al., 2008, Taylor et al., 2015, Salmond et al., 2016).

There is mixed evidence, from a limited number of studies, regarding the importance of the internal infrastructure and 'manmade' features of parks and greenspaces on use and health outcomes (Cohen et al., 2009, Cohen et al., 2010, Van Hecke et al., 2018, World Health Organisation, 2016). Individual studies have found that certain features of greenspaces are more strongly associated with higher levels of physical activity, these include walking/cycling routes, water features, lights, pleasant views, bike racks, and parking areas (Schipperijn et al., 2013, Kärmeniemi et al., 2018). A review found that the presence of different features such as playgrounds and trails influences whether or not spaces are recreationally used by adolescents (Van Hecke et al., 2018).

Gardens have been linked to health outcomes in a number of reviews and primary studies. A systematic review and meta-analysis found that gardening was associated with reduced rates of depression and anxiety symptoms, stress, mood disturbances and with lower body mass index (Soga et al., 2017). The analysis also found that people who took part in gardening had higher quality of life, sense of community, physical activity levels, and cognitive function (Soga et al., 2017). A systematic review found some evidence that allotment gardening was associated with higher levels of wellbeing (Genter et al., 2015). A primary UK study found and that domestic garden coverage appeared to mitigate health deprivation (Dennis and James, 2017). A further UK primary study found associations

between smaller domestic gardens and poorer health outcomes and greater inequalities in health (Brindley et al., 2018).

Quality

Several systematic reviews have concluded that there is currently insufficient evidence regarding the impact of the 'quality' of greenspaces on health outcomes (Houlden et al., 2018, van den Berg et al., 2015). Despite this overall uncertainty, it appears that a number of indicators of quality may be linked with health and wellbeing outcomes.

Several individual primary studies have shown that *perceived* quality and satisfaction with greenspace are more strongly associated with wellbeing outcomes than just the quantity of greenspace. A primary study from the UK focusing on the effect of residential greenness on wellbeing was found to be non-significant after controlling for satisfaction with, and use of, green space (McEachan et al., 2018). Studies from Western Europe have suggested that 'quality', in terms of the maintenance and safety of spaces, has been shown to be particularly important for health outcomes in certain population sub-groups (Balfour and Allen, 2014, South et al., 2015, Cohen et al., 2015, van Dillen et al., 2011). Individual studies have also demonstrated that exposure to more aesthetically pleasing environments are associated with health and wellbeing outcomes. A UK based study found that people living in more 'scenic' environments (which typically included a mix of green, blue, brown and grey (e.g. built) elements) reported better health than people living in less scenic environments, (Seresinhe et al., 2015).

Systematic and non-systematic reviews have shown that the evidence base linking exposure to more or less biodiverse environments and various health and wellbeing outcomes is limited and inconsistent (Sandifer et al., 2015, Horwitz et al., 2015, Aerts et al., 2018, Lovell et al., 2014). Individual primary studies from the UK have suggested links between greater species richness and /or diversity in local greenspaces (Dallimer et al., 2012, Fuller et al., 2007) and interactions with wildlife (Bell et al., 2017, Cox and Gaston, 2016, Dallimer et al., 2012) and more positive wellbeing and quality of life outcomes. Primary studies for the UK and Australia have indicated that there are associations between attitudes towards more biodiverse spaces and associated benefit and use patterns (Harris et al., 2017, Hoyle et al., 2017, Southon et al., 2017, Luck et al., 2011). Studies from the UK and Western Europe have suggested that the visual and auditory experience of wildlife is linked to more positive wellbeing outcomes in some groups, however patterns are inconsistent (Hedblom et al., 2017, Orr et al., 2016, Bell et al., 2017, Ratcliffe et al., 2013).

Equity of availability

There are inequalities in the spatial distribution and accessibility of good quality natural environments across the UK (including both rural and urban settings). Those living in deprived areas, minority ethnic communities, elderly people and those with long term poor health and disabilities typically (though not consistently) have less (physical) access to good quality greenspaces, tend to use them less, and are more likely to have negative perceptions as to their usage of such spaces (McEachan et al., 2018, Ferguson et al., 2018, Jones et al., 2009a, Jones et al., 2009b, Boyd et al., 2018, Bell et al., 2015).

Deprived and disadvantaged groups are underrepresented in nature-based activities associated with wellbeing. Primary studies from the UK have shown that people who are female, older, in poor health, of lower socioeconomic status, belong to ethnic minorities, live in relatively deprived areas with less neighbourhood greenspace and live further from the coast are less likely to visit nature (Boyd et al., 2018) and that people from socio-economically deprived areas rarely participate in citizen science and nature recording schemes at both the national and local levels (Hobbs and White, 2012). Evidence has

demonstrated that there is variation in values ascribed to and uses of different environment types, such as urban forests, between ethnic and cultural groups (Ordóñez-Barona, 2017).

6. Promoting and protecting health with green infrastructure interventions

There is now a small body of evidence which has considered the theory and efficacy of the many different types of urban greenspace interventions. This evidence indicates promising approaches to increasing the use of and potential benefits from different types of green infrastructure (Gubbels et al., 2016, World Health Organization, 2017a). In common with many health promotion actions, green infrastructure interventions also have the potential to worsen health and increase inequalities (Wolch et al., 2014, Haase et al., 2017, Whitehead, 2009).

Multi-component programmes (changes to both the resource and social promotional programmes) appear to be most effective (Hunter et al., 2015, Braubach, 2016), particularly those which are long(er) term (Droomers et al., 2014). However, there is likely to be an interaction between provision, quality and promotion. The quality and usability of existing greenspace in, for example, deprived neighbourhoods is often low, with only less attractive, unsafe places to use, which may reduce the effectiveness of any promotional activities (Jones et al., 2009a).

Physical (e.g. built, environment restoration etc.) interventions

Physical interventions are defined as where new ‘natural’ spaces are created or, existing spaces are linked, modified or improved. This may or may not be done with the specific aim of improving health outcomes. An example may be the planting or trees on a residential street, creation of a new urban park, or creation of a new greenway. Changes to the ‘built’ environment, such as adding benches to a park, improving the road system so that communities can more easily or safely access a park are also included (Lovell et al., Forthcoming).

There is some, mixed, evidence which indicates that creating and increasing greenspaces in urban areas may be effective in promoting good health outcomes (World Health Organisation, 2016, World Health Organization, 2017b, Roberts et al., 2016). Two reviews found limited evidence to show that interventions designed to increase use of greenspaces (such as modifying the space, adding features, and social programmes) were effective in promoting use and increased physical activity (Roberts et al., 2016, Hunter et al., 2015). Studies from Western Europe and the US have suggested that increasing the amount and accessibility and quality of greenspace in areas of deprivation has been linked to improved perceptions and use of such spaces, and to improved health outcomes (e.g. reduced depressive symptoms (Gubbels et al., 2016)) and increased social cohesion in communities with lower socio-economic status (Ward Thompson et al., 2013, King et al., 2015).

There is mixed evidence as to the effects of modifying or improving the state of green infrastructure on health and usage outcomes. A systematic review of randomised (or cluster) randomised controlled trials and controlled before-and-after studies of changes to the built environment found no evidence of positive effect on mental health from ‘urban regeneration’ and ‘improving green infrastructure’, some limited evidence of effect to quality of life and social isolation outcomes from ‘improving green infrastructure’ (Moore et al., 2018). Park and greenspace renovations have been shown to have some positive outcomes on usage. One study (USA) found that compared to parks that had not yet been renovated, improved parks saw more than a doubling of the number of visitors and a substantial increase in energy expended in the parks (Cohen et al., 2015). The greening of vacant sites and street trees are

important aspects of quality of life, walkability and can provide networks of attractive urban spaces (Braubach, 2016). A primary cluster randomized trial found communities (Philadelphia, US) exposed to a greening intervention compared to communities with no intervention demonstrated a significant decrease in feelings of being depressed and worthlessness (South et al., 2018). A primary quasi-experimental study found that changes to the quality or quantity of green space in severely deprived Dutch neighbourhoods resulted in no identifiable favourable change to trends of physical activity and good general health compared to control areas (Droomers et al., 2015). However, some studies from the UK and Western Europe have found no impact to health or even increases in poor health (Droomers et al., 2015). While the controlled evaluation of a Scottish green infrastructure intervention, which included clearing shrubs, installing fences and gates, creating boardwalks and paths and adding signage, found increases in rates of moderate intensity physical activity and community cohesion, significant increases in stress in the community receiving the changes in comparison to the control group were also identified (Ward Thompson et al., 2019). However the differences in stress following the intervention between people who reported actually having visited nature in the last year in both the intervention and the control communities was not found to be significantly different.

Several studies have indicated that combined approaches of modifications to the natural/built environment coupled with social interventions appear to be most effective, however the evidence is mixed (World Health Organisation, 2016, World Health Organization, 2017b, Roberts et al., 2016, Ward Thompson et al., 2019, Hunter et al., 2015). A systematic review found that ‘restructuring the physical environment’ in combination with ‘adding objects to the environment,’ encouraged increased use of greenspaces (Roberts et al., 2016). Adding a ‘prompt or cue’ alongside changes to the environment also appeared to be effective (Roberts et al., 2016). The relevance and impact modification and or addition of new or different features into green infrastructure appears to be dependent on the needs and desires of the target population (Edwards et al., 2015, Roberts et al., 2016).

Social interventions and green prescriptions

Social Interventions are defined as where efforts are made through social activities (e.g. not through physical changes to a space) to improve the health potential of a natural environment, and may include provision of services such as a bus route, media campaigns to increase awareness, or holding community events in a natural environment. It may also include activities where organisations (at all levels and types) that shift their practices, policies and strategies to make use of, or take account of the potential of the natural environment to improve health outcomes (Lovell et al., Forthcoming).

Primary studies have shown that there are differences between what is provided and what is ‘perceived’ as being available and that the provision of greenspace does not guarantee usage and benefit. Some social groups do not necessarily see greenspaces as being provided for ‘them’ (Jones et al., 2009a). A comprehensive review undertaken for the World Health Organisation concluded that interventions to increase the use of urban greenspaces, either informal, personal use or through participation in more formal led activities, are associated with a range of health, social and environmental outcomes, particularly among lower socioeconomic status groups (World Health Organisation, 2016, World Health Organization, 2017b).

Studies tend to demonstrate that outreach and promotional activities can be effective in increasing use of urban greenspaces (predominantly parks) (Hunter et al., 2015, Braubach, 2016) but that they should be targeted to specific population sub-groups or in relation to the outcome of interest (e.g. increasing physical activity behaviours) (Joseph and Maddock, 2016, Elliott et al., 2016, Roberts et al., 2016). A systematic review found (weak but consistent) evidence that ‘demonstration of behaviour’ within greenspace intervention

strategies was associated with increases in use in 95% of the interventions included (Roberts et al., 2016). Individual studies have shown that holding events or siting alternative attractions in urban parks can improve awareness and attitudes (Jones et al., 2008, Black Environment Network, 2005).

Reviews have shown that nature-based interventions and activities, some of which people reach through social prescribing mechanisms, may result in a range of improved health outcomes (Lovell et al., 2015, Annerstedt and Wahrborg, 2011). There is evidence from a number of individual studies which indicate that programmes making use of or based in natural environments can result in positive health outcomes. The Branching Out, targeted at people with mental health difficulties, programme resulted in some positive gains in health status, an increased interest in the natural environment amongst participants, and was demonstrated to be cost-effective (Wilson et al., 2008, Wilson et al., 2010). A range of other programmes have also been demonstrated to result in positive change to multiple indicators of health, wellbeing and quality of life (Carter, 2007, Tees Valley Wildlife Trusts, 2012, New Economics Foundation, 2013, The Mersey Forest, 2016).

7. Promoting pupil mental health, wellbeing and educational outcomes with green infrastructure

There is a limited body of evidence which has begun to demonstrate the value of green infrastructure in and around the school setting for health and wellbeing outcomes in children and young people. The evidence suggests that the presence of or use of green infrastructure is beneficial for a number of health, educational and behavioural outcomes. However, much of the evidence relates to the US or other European nations or is of poor methodological quality thus limiting understanding.

Pupil mental health, wellbeing and psychological

Reviews have shown that participation in outdoor learning and education has been associated with increased self-esteem, self-confidence, trust within relationships and sense of belonging in children and young people, however the evidence is limited in quality and extent (Becker et al., 2017, Educational Endowment Foundation and Sutton Trust, undated, South et al., 2018, Fiennes et al., 2015). A study from the US found that regular group based outdoor learning resulted in greater group cohesion, social connectedness and feelings of solidarity (Richmond et al., 2018).

A number of studies from Europe and the US have demonstrated that views to and use of greener school grounds have been linked to improved student mental wellbeing, attention restoration and recovery from stress (Li and Sullivan, 2016, van den Berg et al., 2016, Wallner et al., 2018). A longitudinal prospective intervention study found the greening of Dutch school yards was associated with higher social wellbeing in comparison to schools that had not been greened, no effect on emotional well-being was found (van Dijk-Wesselius et al., 2018).

A controlled Spanish study found that greener school community settings were associated with higher ability to cope with stressful life events and lower overall rates of stress in 172 urban children (Corraliza et al., 2012).

A review found some evidence that school gardens and gardening was associated with some impact to quality of life, life skills and interpersonal relationships (Ohly et al., 2016a). Benefits included enjoyment and feelings of achievement, satisfaction and pride from nurturing and watching plants grow and the enjoyment of harvesting crops.

Scientific and educational outcomes

A review found evidence of improvements to understanding and process skills relating to geography, science, and design and technology subjects associated with the use of natural environments as settings for learning (Rickinson et al., 2004).

Attainment of skills and academic performance

Reviews have shown that children and young people taking part in outdoor education and learning programmes typically make four months progress on their peers (Educational Endowment Foundation and Sutton Trust, undated, Becker et al., 2017, Fiennes et al., 2015).

A systematic review found some evidence, from a limited number of good quality studies, to suggest that greater amounts of vegetation in and around the school environment is positively linked to a number of academic outcomes (Browning and Rigolon, 2019). Several US studies have found that a greater proportion of trees and/or grassed areas in the school environment is positively associated with academic performance (Kweon et al., 2017,

Sivarajah et al., 2018, Wu et al., 2014, Tuen Veronica Leung et al., 2019). A study undertaken in Barcelona, Spain, found that after controlling for key socio-economic and demographic factors, greater total amounts of green elements around the home and school, and along the commuting route to the school, was associated greater progress in indicators of working memory and superior working memory and greater reduction in inattentiveness (Dadvand et al., 2015).

Motivations to learn, enjoyment of learning and teaching

Reviews have shown that outdoor learning and education is associated with higher educational motivations and can impact positively on some learning outcomes, primarily through adding value to concepts learnt in the classroom and memorable experiences (Rickinson et al., 2004, Becker et al., 2017, Fiennes et al., 2015).

There is some evidence, from primary studies conducted in Germany, to suggest outdoor learning programmes are associated with increases in student motivations to learn (Dettweiler et al., 2017, Dettweiler et al., 2015). A qualitative study of Forest School demonstrated that children and young people, on the whole, appreciate outdoor learning opportunities (Ridgers et al., 2012).

Improved concentration and behaviour

There is some evidence to suggest that greener school grounds are associated with more positive behavioural outcomes (Fiennes et al., 2015). A Swedish study found children aged 4-6 years who could play in greener areas exhibited more positive attentional behaviours than children who had less green areas (Mårtensson et al., 2009). A US study found positive associations between views of surrounding greenness and academic achievement and behaviour after controlling for school socio-economic status, ethnicity, enrolment and building age (Matsuoka, 2010). A longitudinal prospective intervention study found the greening of Dutch school yards was associated with more positive attention restoration after recess in comparison to schools that had not been greened (van Dijk-Wesselius et al., 2018).

Several studies have shown that regular use of local natural environments and environmental settings are associated with improved behaviours (Roe and Aspinall, 2011b, Roe and Aspinall, 2011a, Szczytko et al., 2018). A US study found that children's concentration and engagement was significantly better during observed lessons conducted after a lesson in nature in comparison to a previous indoor lesson (Kuo et al., 2018). A UK study found participation in residential natural environment based learning had positive impacts on students' behaviour and attendance, helping some students, particularly those at risk of exclusion, to more fully engage with school (Kendall and Rodger, 2015).

Opportunities for physical activity

Small scale studies have demonstrated that outdoor learning is associated with higher levels of physical activity in comparison to other settings (e.g. the normal school day) (Aronsson et al., 2014, Mygind, 2007, Romar et al., 2018, Lovell, 2009). A Finnish study found lower levels of sedentary, and increases in light to moderate intensity physical activity, on outdoor learning days in comparison to traditional school days (Romar et al., 2018).

There is some evidence that greener and the greening of schools' grounds is associated with improved physical health and higher levels of physical activity (Arbogast et al., 2009, Mårtensson et al., 2014). A controlled experimental study found a greater increase in the percentage of time spent in moderate and moderate-to-vigorous intensity of activity against baseline in the 6 US schools in low income areas that had been provided with gardens in

comparison to the rates of activity in 6 schools with no new garden (Wells et al., 2014). A primary comparative study of the impact of greenery in school grounds on Swedish school children's physical activity found that spaces with a mix of built and green were the most used (Mårtensson et al., 2014). A longitudinal prospective intervention study found the greening of Dutch school yards was associated with higher rates of physical activity for amongst girls in comparison to rates in schools that had not been greened (van Dijk-Wesselius et al., 2018).

Limitations of the evidence base and additional research needs

Many of the reviews included in this paper conclude that whilst there is a substantial body of useful evidence which taken as a whole indicates the beneficial impacts of green infrastructure for health and wellbeing, there are limitations to how useful the evidence is. These limitations include the poor quality and high levels of heterogeneity between studies and the patchy nature of the evidence base with a lack of evidence relating to certain exposures, population sub-groups and explanatory pathways. Currently much of the evidence base is cross-sectional though there is an increasing use of longitudinal cohort data and of experimental designs.

The plurality of the measures of exposure and outcomes used can also be considered a limitation. Currently exposures and uses of the environment are assessed in a number of different ways, according, for example, to 1) the amount of local-area greenspace, 2) greenspace type, 3) number, frequency and type of visits to greenspace, 4) views of greenspace, 5) greenspace proximity and accessibility (physical or perceptual), and 6) 'connection to nature' (Houlden et al., 2018). Health and wellbeing outcomes are similarly diverse. This limits the potential to conduct meta-analyses.

The evidence base is currently of limited applicability for determining the most appropriate size, location, configuration, connectivity, composition, characteristics and qualities for health and wellbeing outcomes. This is most likely due to the relative youth of the field and the heterogeneity of the evidence. There is a pressing need for further developmental work on accessibility, space and quality indicators.

It is not yet clear how transferable and applicable the evidence is between different contexts. It is possible the health and wellbeing impacts of green infrastructure are highly socially, culturally and spatially contextual.

There is currently a relatively basic understanding of who is exposed to, uses and benefits from green infrastructure. The assumptions made about visits to spaces in the immediate neighbourhood (which is still underpinning much of the research) are simplistic. Inequalities in exposures, uses and benefits are also poorly understood. Conversely, there is also a basic understanding of the potential dis-benefits of green infrastructure. Further research could help clarify the adverse outcomes of green infrastructure, such as the 'rewilding' of urban spaces and the potential impacts on pollen, vectors, disease and usage patterns.

Further work is needed to identify and develop a coherent and applicable set of robust metrics suitable for use with a green infrastructure framework. Challenges include the heterogeneous and patchy nature of the evidence base and the need for different metrics for different scales (e.g. national and regional and local). A process of synthesis and prioritisation would help identify sets of provision and impact/outcome metrics for the key benefit categories.

Conclusions and implications of the current evidence for green infrastructure planning, delivery and usage for health and wellbeing outcomes

Does the evidence support the inclusion of health and wellbeing as a key benefit of green infrastructure?

- Currently the evidence base demonstrates that green infrastructure has a positive influence on population and individual level health and wellbeing and should be considered as a key benefit category of green infrastructure provision.
- There is established, but variable or incomplete, evidence which indicates that more frequent exposure to green infrastructure has a positive influence on mortality rates, certain types of morbidity, mental health, quality of life and is associated with less stark inequalities in health.

Does the evidence indicate how green infrastructure benefits or harms health and wellbeing?

- There is some un-certainty as to how green infrastructure benefits health and wellbeing.
- It is likely that green infrastructure influences health and wellbeing through direct and 'active' pathways such as promoting positive mental health states, providing a context for and motivation for physically activity and recreation and allowing people to experience nature. However, the evidence base is incomplete and sometimes inconsistent.
- It is also likely that green infrastructure influences health and wellbeing through indirect or 'passive' pathways such as contributing to healthy micro-biomes and better nutrition, and through the mitigation of health risks such as heat island effects, noise pollution, flooding and poor air quality. Whilst these pathways are likely, the evidence base is limited, and in some cases incomplete and inconsistent.
- There is established but incomplete evidence which suggests that green infrastructure can result in ecosystem dis-benefits such as exposure to pollen or zoonotic disease which have the potential to harm health and wellbeing.
- There is established but incomplete evidence which suggests that different types of exposures influence different health and wellbeing outcomes and that visual and auditory as well as physical exposure (e.g. visiting a park, tending the garden) are important. Some indirect pathways (e.g. mitigation of air pollution) do not depend on such direct use or exposure for health benefit.
- The evidence base suggests that health and wellbeing outcomes of exposure to green infrastructure through both direct/active or indirect/passive pathways are highly context dependant.

Does the evidence indicate who benefits from green infrastructure and in what ways?

- All social groups are likely to benefit from exposure to and/or use of green infrastructure, however the evidence is currently inconsistent on who benefits, in what ways, and to what degree.
- Some groups, including more socio-economically deprived and disadvantaged populations, appear to disproportionately benefit from greener living environments. The evidence base suggests that there is no consistent pattern in the distribution of green infrastructure according to socio-demographics; in some areas more socio-economically deprived and disadvantaged groups have similar provision of green infrastructure to less socio-economically deprived and disadvantaged groups, in other areas there are inequalities in provision. There is some evidence to suggest that green infrastructure tends to be poorer quality in more socio-economically deprived and disadvantaged areas.
- There is established but variable or incomplete evidence which suggests that there is variation in how different social groups feel about, (are able to) use, and respond or benefit from green infrastructure.

Does the evidence clarify what is 'good' or 'good enough' green infrastructure for health and wellbeing outcomes?

- Currently the evidence base has limited utility for clarifying what is 'good' or 'good enough' green infrastructure. Whilst it is likely that the type, amount, location/proximity, and quality of green infrastructure are key factors in health and wellbeing outcomes the evidence is, as of yet, incomplete, variable and in some cases inconsistent.
- Despite the uncertainty the evidence indicates that:
    - Greener living environments are associated with better health and wellbeing.
    - Different types of green infrastructure afford different benefits and that mixed provision (e.g. a mix of publicly accessible greenspaces, domestic and shared gardens, green routes and street trees) is most likely to be beneficial.
    - Different sizes and configurations of greenspaces and other forms of green infrastructure such as green routes, support different types, frequencies and durations of use. Again, mixed provision with appropriate connectivity is most likely to be beneficial.
    - It is likely that greenspaces that are closer to the home or education/work place are very important, however 'accessibility' varies according to factors such as urban form, terrain, climate, availability of transport, and to personal factors such as preferences, physical capacity to walk, competing demands on time etc. It also appears that people are selective in their choice of destination and that proximity is not necessarily the primary factor. The *perception* of proximity appears to be as important as objective proximity.
    - Both publicly accessible and private greenspace (e.g. domestic gardens, institutional spaces) have a role in promoting health and wellbeing.
    - Better quality and well-maintained green infrastructure is associated with better health and wellbeing outcomes. The *perception* of quality, which is highly variable between socio-cultural groups, is again important.
    - It is likely that the internal infrastructure and 'manmade' features of parks and greenspaces and other forms of green infrastructure (e.g. benches, lighting,

play areas) have a contributory influence on use and subsequent health and wellbeing outcomes.

- The evidence suggests that the value of different types, amounts and locations of green infrastructure for health and wellbeing outcomes is likely to be highly contextual; what is appropriate in one locale may not be appropriate in another.

Does improving the amount, quality and connectivity of green infrastructure improve health and wellbeing?

- Currently the evidence base has limited utility (there are a very small number of robust studies and demonstrating health or wellbeing gain resulting from environmental change is complex) for clarifying how the provision of new green infrastructure, or the modification and adaptation of, or changes to the management or promotion of existing green infrastructure, could be used to improve health and wellbeing.
- Despite the uncertainty the evidence indicates that:
    - In new developments mixed provision (e.g. a mix of different sizes and types of publicly accessible greenspaces, domestic and shared gardens, green routes, street trees etc.) with appropriate connectivity is most likely to be beneficial.
    - Improving the quality and management of green infrastructure may have a positive impact on perceptions and use.
    - Improving knowledge of and accessibility of spaces may have a positive impact on perceptions and use.
    - Interventions to promote use likely need to be plural, involving changes to physical spaces in addition to complementary social programmes.
    - Some specific health and wellbeing interventions and activities (such as those delivered via social prescribing mechanisms) which make use of certain types of green infrastructure have been found to have the potential to result in positive outcomes.
    - There is evidence that new, or modifications to the provision or management of existing green infrastructure can exacerbate inequalities in health through processes such as gentrification or inequal access.
- The evidence suggests that the provision, modification or use of green infrastructure to promote health and wellbeing is most likely to be successful if there is a good understanding of the local social, cultural and economic context, of the desires and perceptions of local communities, where the health needs of target populations are understood, of the theoretical ways in which the environmental change may influence health, and where linkages are made with, and buy-in gained from wider networks of social and health services.

Is there a set of suitable metrics for assessing or monitoring the health benefits of green infrastructure?

- As of yet there does not appear to be an applicable set of robust health and wellbeing metrics ready to be tested. A process of synthesis and prioritisation and then testing and refinement would help identify sets of need/provision and impact/outcome metrics for the key benefit categories at different spatial scales and in different contexts.

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Appendices

Appendix 1. Search terms and evidence databases used

Method summary

Due to time and resource imitations a systematised rapid scoping review[6] was used to identify and summarise key empirical evidence relating to the broad health and wellbeing topics as requested for the Green Infrastructure standards development and in consultation with Natural England, Defra and the wider stakeholder group.

Search Strategy:

Iterative and strategic searches were conducted for each benefit category. Individual search terms and/or strings as used in each database were not recorded in full as for a systematic review. The number of returns for each individual search were not recorded. Searches were conducted in the Spring of 2019.

Search terms:

Relevant search terms were combined for each topic. The choice of and combination of search terms and truncation and wildcard variations were modified for use in different databases as appropriate.

1) Health and wellbeing terms

Health; Mental Health; Cardiovascular; Diabetes; Cancer; Mortality; Pregnancy; Birth; Wellbeing; Quality of Life; Life satisfaction; Stress; Emotion; Anxiety; Cognitive function; Concentration; Body weight; Obesity

2) Pathways terms

Physical activity; Leisure; Recreation; Exercise; Social cohesion; Social contact; Health behaviours; Motivation; Learning; Education; Academic; Connection to nature; Nature connectedness; Microbiome; Heat island; Noise; Flooding; Air quality; Pollution; Nutrition

3) Demographic terms

Infant; Child; Adult; Young people; Ageing; Ethnicity; Socio-economic status; Deprivation; Inequality

4) Green infrastructure and environmental terms

Greenspace; Bluespace; Natural environment; Parks; Gardens; Woodlands; Street trees; Greenways; Biodiversity; Ecosystem; Zoonotic; Proximity; Accessibility;

[6] See Grant, M. J., & Booth, A. (2009). A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Info Libr J, 26*(2), 91-108. doi: 10.1111/j.1471-1842.2009.00848.x for details of the review approach.

Availability; Neighbourhood; Size; Walkability; Active transport; Quality; Urban; Schools; Streets

5) Methodology terms

Systematic review; Meta-analysis; Longitudinal; Cohort; Intervention

Academic databases searched:

PubMed; PsycINFO; Scopus; Environment Complete; Web of Science; Google Scholar

Citation searching:

The citations (forward and backward) of key papers were searched:

- Twohig-Bennett, C. and A. Jones (2018). "The health benefits of the great outdoors: A systematic review and meta-analysis of greenspace exposure and health outcomes." Environmental Research 166: 628-637.
- van den Berg, M., W. Wendel-Vos, M. van Poppel, H. Kemper, W. van Mechelen and J. Maas (2015). "Health Benefits of Green Spaces in the Living Environment: A Systematic Review of Epidemiological Studies." Urban Forestry & Urban Greening 14(4): 806-816.
- Houlden, V., et al. (2018). "The relationship between greenspace and the mental wellbeing of adults: A systematic review." Plos One 13(9): e0203000.
- Lachowycz, K. and A. P. Jones (2011). "Greenspace and obesity: a systematic review of the evidence." Obes Rev 12(5): e183-189.
- Thompson Coon, J., K. Boddy, K. Stein, R. Whear, J. Barton and M. Depledge (2011). "Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review." Environ. Sci. Technol. 45: 1761.
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Note: The review approach was informed by the methodologies as outlined in the Defra review guidance (Collins et al. 2015) and seeks to present a fair interpretation of the evidence base. However, whilst robust systematic reviews, meta-analyses and robust primary evidence were prioritised, it must be noted the review itself is not systematic or exhaustive and the quality of the evidence was not assessed.

Appendix 2. Health and wellbeing evidence schedule

Table 2.Health and wellbeing evidence schedule contains examples of evidence relating to each topic.

The table is not exhaustive nor representative of the totality of evidence.

Primary evidence – individual empirical studies
Secondary evidence – reviews and syntheses
Tertiary evidence – policy and position statement, guidance

2.C. Evidence Topic	Title	Source	Annotation	Primary Evidence	Secondary Evidence	Tertiary Evidence
(F) Health and Wellbeing						
Health and wellbeing outcomes of exposure to green infrastructure: Physical health and wellbeing Health and wellbeing outcomes of exposure to green infrastructure: Mental health and wellbeing	Twohig-Bennett, C. and A. Jones (2018). The health benefits of the great outdoors: A systematic review and meta-analysis of greenspace exposure and health outcomes. Environmental Research 166: 628-637.	https://www.ncbi.nlm.nih.gov/pubmed/29982151	Systematic review and meta-analysis finding that increased greenspace exposure is associated with range of positive health outcomes including decreased risk of Diabetes TII and all-cause mortality, with reduced incidences of stroke, hypertension, asthma, and coronary heart disease, and with increased rates of good self-reported health.		△	
	van den Berg, M., W. Wendel-Vos, M. van Poppel, H. Kemper, W. van Mechelen and J. Maas (2015). Health Benefits of Green Spaces in the Living Environment: A Systematic Review of Epidemiological Studies. Urban Forestry & Urban Greening 14(4): 806-816.	https://www.sciencedirect.com/science/article/pii/S1618866715001016	Systematic review finding good evidence for a significant positive association between the quantity of green space (in relation to the home residence) and all-cause mortality, and moderate evidence for perceived general health.		△	
	Dzhambov, A. M., D. D. Dimitrova and E. D. Dimitrakova (2014). Association between residential greenness and birth weight: Systematic review and meta-analysis. Urban Forestry & Urban Greening 13(4): 621-629.	https://www.sciencedirect.com/science/article/pii/S1618866714000995	Systematic review and meta-analysis finding the neighbourhood greenness for pregnant women within a 100-m buffer is positively, but weakly, associated with birth weight.		△	
	Blaschke, S. (2017). The role of nature in cancer patients' lives: a systematic review and qualitative meta-synthesis. BMC Cancer 17(1): 370.	https://www.ncbi.nlm.nih.gov/pubmed/28545539	Systematic review and meta-synthesis (of qualitative literature) findings that experience of and use of the natural environment (through different modes and exposure routes) helped patients manage the clinical and personal consequences of cancer.		△	
	Sandifer, P. A., Sutton-Grier, A. E., & Ward, B. P. (2015). Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: Opportunities to enhance health and biodiversity conservation. Ecosystem Services, 12, 1-15.	https://www.sciencedirect.com/science/article/pii/S2212041614001648	Literature review findings that some evidence that exposure to microbial biodiversity is associated with reduced rates of certain allergic and respiratory diseases.		△	

2.C. Evidence Topic	Title	Source	Annotation	Primary Evidence	Secondary Evidence	Tertiary Evidence
	James, P., R. F. Banay, J. E. Hart and F. Laden (2015). A Review of the Health Benefits of Greenness. Current Epidemiology Reports 2(2): 131-142.	https://www.ncbi.nlm.nih.gov/pubmed/26185745	Literature review finding that greater residential greenness is protective against cardiovascular disease, mortality and birth weight.		▲	
	van den Berg, M., W. Wendel-Vos, M. van Poppel, H. Kemper, W. van Mechelen and J. Maas (2015). Health Benefits of Green Spaces in the Living Environment: A Systematic Review of Epidemiological Studies. Urban Forestry & Urban Greening 14(4): 806-816.	https://www.sciencedirect.com/science/article/pii/S1618866715001016	Systematic review finding good evidence for a significant positive association between the quantity of green space (in relation to the home residence) and self-perceived mental health.		△	
	McEachan, R. R. C., T. C. Yang, H. Roberts, K. E. Pickett, D. Arseneau-Powell, C. J. Gidlow, J. Wright and M. Nieuwenhuijsen (2018). Availability, use of, and satisfaction with green space, and children's mental wellbeing at age 4 years in a multicultural, deprived, urban area: results from the Born in Bradford cohort study. Lancet Planet Health 2(6): e244-e254	https://www.ncbi.nlm.nih.gov/pubmed/29880156	Primary analysis of birth cohort data linked to environmental data showing that ethnicity moderated relationships between residential greenspace and mental wellbeing. After adjusting for relevant confounders, residential green space was associated with fewer internalising behavioural difficulties, and with fewer total behavioural difficulties. The effect of residential greenness on wellbeing was found to be non-significant after controlling for satisfaction with, and use of, green space.	●		
	McCormick, R. (2017). Does Access to Green Space Impact the Mental Well-being of Children: A Systematic Review. J Pediatr Nurs 37: 3-7.	https://www.ncbi.nlm.nih.gov/pubmed/28882650	Systematic review finding that access to green space is associated with improved mental well-being, overall health and cognitive development of children aged 0-18 years.		△	
	James, P., R. F. Banay, J. E. Hart and F. Laden (2015). A Review of the Health Benefits of Greenness. Current Epidemiology Reports 2(2): 131-142.	https://www.ncbi.nlm.nih.gov/pubmed/26185745	Literature review finding that greater residential greenness is protective against adverse mental health outcomes.		▲	
	Houlden, V., et al. (2018). The relationship between greenspace and the mental wellbeing of adults: A systematic review. Plos One 13(9): e0203000.	https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0203000	Systematic review finding evidence of associations between the amount of local-area greenspace and life satisfaction (hedonic wellbeing).		▲	
	Vanaken, G. J. and M. Danckaerts (2018). Impact of Green Space Exposure on Children's and Adolescents' Mental Health: A Systematic Review. Int J Environ Res Public Health 15(12).	https://www.ncbi.nlm.nih.gov/pubmed/30486416	Systematic review finding a positive association between green space exposure and children's emotional and behavioural difficulties, including hyperactivity and inattention problems.		▲	
	Tillmann, S., et al. (2018). Mental health benefits of interactions with nature in children and teenagers: a systematic review. J Epidemiol Community Health 72(10): 958-966.	https://www.mdpi.com/1660-4601/15/6/1072	Systematic review finding positive relationships between exposure to natural envinrments and mental health outcomes in children aged 0-18 years.		▲	
	South, E. C., Hohl, B. C., Kondo, M. C., MacDonald, J. M., & Branas, C. C. (2018). Effect of greening vacant land on mental health of community-dwelling adults: a cluster randomized trial . JAMA network open, 1(3), e180298-e180298.	https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2688343	Primary cluster randomised controlled trial of the effects of greening ‘vacant lots’ in Philiadelphia, USA, finding a significant decrease in feeling depressed and worthless, as well as a nonsignificant reduction in overall self-reported poor mental health	●		

2.C. Evidence Topic	Title	Source	Annotation	Primary Evidence	Secondary Evidence	Tertiary Evidence
			in the groups exposed to the intervention in comparison to the control groups.			
	Helbich, M., D. de Beurs, M.-P. Kwan, R. C. O'Connor and P. P. Groenewegen (2018). Natural environments and suicide mortality in the Netherlands: a cross-sectional, ecological study. The Lancet Planetary Health 2(3): e134-e139.	https://www.sciencedirect.com/science/article/pii/S2542519618300330	Primary analysis of Dutch cross-sectional data showed that a greater proportion of green space was associated with a reduced suicide risk compared with areas with less green space.	●		
	Mensah, C. A., Andres, L., Perera, U., & Roji, A. (2016). Enhancing quality of life through the lens of green spaces: A systematic review approach. International Journal of Wellbeing, 6(1).	http://internationaljournalofwellbeing.org/index.php/ijow/article/view/445	Systematic review finding that greenspace enhances quality of life through multiple social, economic, and environmental pathways.		▲	
	Yeo, N.L., Elliott, L.R., Bethel, A., White, M.P., Dean, S., & Garside, R. (2019). Indoor Nature Interventions for Health and Wellbeing of Older Adults in Residential Settings: A Systematic Review. Gerontologist, gnz019.	https://academic.oup.com/gerontologist/advance-article-abstract/doi/10.1093/geront/gnz019/5382625?redirectedFrom=fulltext	Systematic review finding quality of life among elderly care home dwellers may be enhaced by structured nature contact indoors (gardening/horticulture) but mixed support for 'virtual' nature.		△	
	McMahan EA, Estes D. The effect of contact with natural environments on positive and negative affect: A meta-analysis. The Journal of Positive Psychology. 2015;10(6):507-19.	https://doi.org/10.1080/17439760.2014.994224	Meta-analysis finding that exposure to nature was associated with a moderate increase in positive affect and with a decrease in negative affect relative to comparison conditions.		▲	
Variation in health outcomes by socio-demographic group	Kabisch, N., M. van den Bosch and R. Lafortezza (2017). The health benefits of nature-based solutions to urbanization challenges for children and the elderly – A systematic review. Environmental Research 159: 362-373.	https://www.ncbi.nlm.nih.gov/pubmed/28843167	Systematic review finding some evidence of positive associations between exposure to urban greenspace and reduced risk factors for children and elderly people and the with the promotion of health-related behaviours and resulting positive health outcomes, benefits were context dependant.		▲	
	van den Berg, M., Wendel-Vos, W., van Poppel, M., Kemper, H., van Mechelen, W., & Maas, J. (2015). Health benefits of green spaces in the living environment: A systematic review of epidemiological studies. Urban Forestry & Urban Greening, 14(4), 806-816.	https://www.sciencedirect.com/science/article/pii/S1618866715001016	Systematic review finding that positive association between the quantity of green space (in relation to the home residence) and self-perceived mental health vary according to gender, age and social economic status.		▲	
	McCormick, R. (2017). Does Access to Green Space Impact the Mental Well-being of Children: A Systematic Review. J Pediatr Nurs 37: 3-7.	https://www.ncbi.nlm.nih.gov/pubmed/28882650	Systematic review finding that access to greenspace is associated with associated with improved mental well-being, overall health and cognitive development of children (aged 0-18 years old).		▲	
Active pathways between green infrastructure exposure and health and wellbeing outcomes: Physical activity	Lachowycz, K. and A. P. Jones (2011). Greenspace and obesity: a systematic review of the evidence. Obes Rev 12(5): e183-189.	https://www.ncbi.nlm.nih.gov/pubmed/21348919	Systematic review finding exposure to greenspace positively or weakly related to obesity-related health indicators.		△	
	Thompson Coon, J., K. Boddy, K. Stein, R. Whear, J. Barton and M. Depledge (2011). Does participating in physical activity in outdoor natural environments have a greater effect on physical and	https://www.ncbi.nlm.nih.gov/pubmed/21291246	Systematic review finding that when compared with exercising indoors, exercising in natural environments is associated with greater feelings of revitalization and positive engagement, decreases in		△	

2.C. Evidence Topic	Title	Source	Annotation	Primary Evidence	Secondary Evidence	Tertiary Evidence
	mental wellbeing than physical activity indoors? A systematic review. Environ. Sci. Technol. 45: 1761.		tension, confusion, anger, and depression, and increased energy.			
	Hunter, R. F., Christian, H., Veitch, J., Astell-Burt, T., Hipp, J. A., & Schipperijn, J. (2015). The impact of interventions to promote physical activity in urban green space: a systematic review and recommendations for future research. Social Science & Medicine, 124, 246-256.	https://www.sciencedirect.com/science/article/pii/S0277953614007837	Systematic review finding some evidence that physical changes to environments, phsyical activity programs, and physical activity programs that are combined with physical changes to the environment, increase urban green space use and activity rates.		△	
Active pathways between green infrastructure exposure and health and wellbeing outcomes: Recreation	Mansfield, l et al. (2018) A systematic review of outdoor recreation (in green and blue spaces), families and wellbeing. What Works Wellbeing.	https://whatworkswellbeing.org/product/family-and-outdoor-recreation/	Systematic review finding that different types of outdoor physical activities are associated with improved subjective wellbeing through improvements in self-competence learning and identity, a sense of escapism, relaxation and sensory experience, and improving social bonding as a family.		△	
	Natural England (2018). Monitor of Engagement with the Natural Environment: The national survey on people and the natural environment. Headline Report 2018.	https://www.gov.uk/government/collections/monitor-of-engagement-with-the-natural-environment-survey-purpose-and-results	Range of reports of primary data collection demonstrating the nature of and participation rates of outdoor recreation in different environments.			☆
Active pathways between green infrastructure exposure and health and wellbeing outcomes: Connection to nature	Capaldi CA, Dopko RL, Zelenski JM. (2014) The relationship between nature connectedness and happiness: a meta-analysis. Frontiers in Psychology. 5.	http://www.frontiersin.org/Journal/Abstract.aspx?s=196&name=cognitive_science&ART_DOI=10.3389/fpsyg.2014.00976	Meta-analysis finding that people who report they are more connected to nature tended to experience more positive affect, vitality, and life satisfaction compared to who report they are less connected to nature.		△	
	Restall, B. and Conrad, E., (2015). A literature review of connectedness to nature and its potential for environmental management. Journal of Environmental Management, 159, pp.264-278.	https://www.sciencedirect.com/science/article/pii/S0301479715300748	A literature review finding that the then evidence base on connection to nature has limited application to environmental management questions and is it not yet clear if or how findings can be translated to different populations.		△	
Passive pathways between green infrastructure exposure and health and wellbeing outcomes: Microbiome	Hough, R. (2014). Biodiversity and human health: evidence for causality? Biodiversity and Conservation, 23(2), 267-288.	https://link.springer.com/article/10.1007%2Fs10531-013-0614-1	Literature review findings that there are associations between exposure to greater biodiversity and the internal microbiome.		△	
	Rook, G. A. (2013). Regulation of the immune system by biodiversity from the natural environment: an ecosystem service essential to health. Proceedings of the National Academy of Sciences, 110(46), 18360-18367.	https://www.pnas.org/content/110/46/18360.short	Literature review and commentary paper finding that exposure to biodiverse environments is associated with more positive immunoregulatory health through micro-biome pathways.		△	
	Flies, E. J., Skelly, C., Negi, S. S., Prabhakaran, P., Liu, Q., Liu, K., ... & Weinstein, P. (2017). Biodiverse green spaces: a prescription for global urban health. Frontiers in Ecology and the Environment, 15(9), 510-516.	https://esajournals.onlinelibrary.wiley.com/doi/pdf/10.1002/fee.1630	Literature review and concept paper indicating the potential for biodiverse urban green spaces to promote healthy human microbiome and consequently a range of positive health outcomes [note: no actual empirical studies linking urban		△	

2.C. Evidence Topic	Title	Source	Annotation	Primary Evidence	Secondary Evidence	Tertiary Evidence
			biodiversity->healthy microbiome->health outcomes].			
	Pearson, A.L., Rzotkiewicz, A., Pechal, J.L., Schmidt, C.J., Jordan, H.R., Zwickle, A., Benbow, M.E., (2019). Initial Evidence of the Relationships between the Human Postmortem Microbiome and Neighborhood Blight and Greening Efforts. Annals of the American Association of Geographers, 1-21.	https://doi.org/10.1080/24694452.2018.1519407	Empirical study of the human microbiome and residential neigbourhood environments using post-mortem analysis of 48 individuals in Detroit, USA. High microbial biodiversity and high levels of commensal micro-organisms found in individuals resident in 'green remediation' areas (tree planting, urban farms etc.).	●		
Passive pathways between green infrastructure exposure and health and wellbeing outcomes: heat islands	Gunawardena, K. R., M. J. Wells and T. Kershaw (2017). Utilising green and bluespace to mitigate urban heat island intensity. Science of The Total Environment 584: 1040-1055.	https://www.sciencedirect.com/science/article/pii/S0048969717301754	Meta-analysis of the the mitigation effects of urban heat island intensity by urban green/bluespaces.	●		
	Koc, C. B., Osmond, P., & Peters, A. (2018). Evaluating the cooling effects of green infrastructure: A systematic review of methods, indicators and data sources. Solar Energy, 166, 486-508.	https://www.sciencedirect.com/science/article/pii/S0038092X18302172	Systematic review focussing on trends, gaps and geographical patterns in evidence (rather than effects). Indicates that most evidence is at micro scale, and relatively little evidence on impact of GI connectivity, spatial heterogeneity on cooling.		▲	
	Bowler, D. E., Buyung-Ali, L., Knight, T. M., & Pullin, A. S. (2010). Urban greening to cool towns and cities: A systematic review of the empirical evidence. Landscape and urban planning, 97(3), 147-155.	https://www.sciencedirect.com/science/article/pii/S0169204610001234	Systematic review finding some, limited, evidence that larger parks and those with trees tend to be cooler during the day.		▲	
	van den Bosch, M. and Å. Ode Sang (2017). Urban natural environments as nature-based solutions for improved public health – A systematic review of reviews. Environ Res 158: 373-384.	https://www.sciencedirect.com/science/article/pii/S0013935117310241	Systematic literature review finding that natural environments in urban areas positively associated with strong evidence for heat reduction from urban natural environments, with potential mediating effect of urban natural environments on reduced cardio-vascular disease related mortality.		▲	
	Saaroni, H., Amorim, J.H., Hiemstra, J.A., Pearlmutter, D., (2018). Urban Green Infrastructure as a tool for urban heat mitigation: Survey of research methodologies and findings across different climatic regions. Urban Climate 24, 94-110.	https://doi.org/10.1016/j.uclim.2018.02.001	Literature review of 89 studies. Found park cool island (PCI) effects ranging approx. 1.5 °C–3.5 °C, irrespective of climate zone. Larger green spaces tend to have larger cooling effects, and street trees significant cooling effect.		▲	
Passive pathways between green infrastructure exposure and health and wellbeing outcomes: noise	Dzhambov, A. M. and D. D. Dimitrova (2014). Urban green spaces' effectiveness as a psychological buffer for the negative health impact of noise pollution: a systematic review. Noise & Health 16(70): 157-165.	https://www.ncbi.nlm.nih.gov/pubmed/24953881	Systematic review finding moderate evidence that presence of vegetation can reduce the negative perception of noise.		▲	
	Gidlöf-Gunnarsson, A., & Öhrström, E. (2007). Noise and well-being in urban residential environments: The potential role of perceived	https://www.sciencedirect.com/science/article/pii/S0169204607000722	Primary analysis of questionnaire data showed that greater availability of greenspaces were linked to enhanced well-being by reducing long-term noise	●		

2.C. Evidence Topic	Title	Source	Annotation	Primary Evidence	Secondary Evidence	Tertiary Evidence
	availability to nearby green areas. Landscape and urban planning, 83(2), 115-126.		annoyances and prevalence of stress-related psychosocial symptoms, and by increasing the use of outdoor spaces.			
	Salmond, J. A., Tadaki, M., Vardoulakis, S., Arbuthnott, K., Coutts, A., Demuzere, M., ... & McInnes, R. N. (2016). Health and climate related ecosystem services provided by street trees in the urban environment. Environmental Health, 15(1), S36.	https://ehjournal.biomedcentral.com/articles/10.1186/s12940-016-0103-6	Literature review finding there is some evidence that street trees mask urban noise with subsequent impacts to related health outcomes.		▲	
Passive pathways between green infrastructure exposure and health and wellbeing outcomes: flooding	Suppakittpaisarn, P., Jiang, X., & Sullivan, W. C. (2017). Green Infrastructure, Green Stormwater Infrastructure, and Human Health: A Review. Current Landscape Ecology Reports, 2(4), 96-110.	https://link.springer.com/article/10.1007/s40823-017-0028-y	Systematic review finding little evidence that rain gardens, bio-swales, green roofs, or biodiverse plantings have a positive impact to health.		▲	
	Kondo, M. C., Low, S. C., Henning, J., & Branas, C. C. (2015). The impact of green stormwater infrastructure installation on surrounding health and safety. American journal of public health, 105(3), e114-e121.	https://ajph.aphapublications.org/doi/abs/10.2105/AJPH.2014.302314	Primary comparative analysis of intervention and randomly chosen matched control site data of urban green stormwater infrastructure instalments found significant reductions in narcotics possession in areas with installations.	●		
	Houghton, A., Castillo-Salgado, C., 2017. Health Co-Benefits of Green Building Design Strategies and Community Resilience to Urban Flooding: A Systematic Review of the Evidence. International Journal of Environmental Research and Public Health 14.	https://doi.org/10.3390/ijerph14121519	Systematic review of green building strategies (specifically in US LEED framework). Suggest green design can reduce flood-related risks of waterborne disease, morbidity and mortality, and psychological harm.		▲	
	Farrugia, S., Hudson, M.D., McCulloch, L., (2013). An evaluation of flood control and urban cooling ecosystem services delivered by urban green infrastructure. International Journal of Biodiversity Science, Ecosystem Services & Management 9, 136-145.	https://doi.org/10.1080/21513732.2013.782342	Primary Southampton-based study proposing tool for assessing flood control (and cooling) delivered by urban GI.	●		
Passive pathways between green infrastructure exposure and health and wellbeing outcomes: Air quality	Salmond, J. A., Tadaki, M., Vardoulakis, S., Arbuthnott, K., Coutts, A., Demuzere, M., ... & McInnes, R. N. (2016). Health and climate related ecosystem services provided by street trees in the urban environment. Environmental Health, 15(1), S36.	https://ehjournal.biomedcentral.com/articles/10.1186/s12940-016-0103-6	Literature review finding there is limited evidence of whether and how street trees impact on air quality and subsequent related health outcomes.		▲	
	Escobedo, F. J., Kroeger, T., & Wagner, J. E. (2011). Urban forests and pollution mitigation: Analyzing ecosystem services and disservices. Environmental pollution, 159(8-9), 2078-2087.	https://www.sciencedirect.com/science/article/pii/S0269749111000327	Literature review finding there is currently little evidence of the efficacy of urban forests in mitigating pollution.		▲	
	Pugh, T.A.M., MacKenzie, A.R., Whyatt, J.D., Hewitt, C.N., (2012). Effectiveness of green infrastructure for improvement of air quality in	https://pubs.acs.org/doi/abs/10.1021/es300826w	Modelling study indicating value for deposition of NO2 and PM on vegetation within urban street canyons – model suggests in this setting vegetation	●		

2.C. Evidence Topic	Title	Source	Annotation	Primary Evidence	Secondary Evidence	Tertiary Evidence
	urban street canyons. Environmental Science and Technology 46.		could reduce NO2 concentration by 40% and PM by 60%.			
	Abhijith, K.V., Kumar, P., Gallagher, J., McNabola, A., Baldauf, R., Pilla, F., Broderick, B., Di Sabatino, S., Pulvirenti, B., (2017). Air pollution abatement performances of green infrastructure in open road and built-up street canyon environments – A review. Atmospheric Environment 162, 71-86.	https://doi.org/10.1016/j.atmosenv.2017.05.014	Literature review of GI for air pollution control. Finds evidence for the value of low hedges/vegetation in street canyons, but adverse impacts of high canopy vegetation in this setting. In open road settings, wide, low porosity and tall vegetation found to be beneficial for air quality.		▲	
Passive pathways between green infrastructure exposure and health and wellbeing outcomes: nutrition	Russo, A., Escobedo, F. J., Cirella, G. T., & Zerbe, S. (2017). Edible green infrastructure: An approach and review of provisioning ecosystem services and disservices in urban environments. Agriculture, ecosystems & environment, 242, 53-66.	https://www.sciencedirect.com/science/article/pii/S0167880917301457	Literature review finding that urban edible green infrastructure (including some forms of urban and peri-urban agriculture) contribute to sustainability and food security but are also linked to disbenefits such as exposure to heavy metals and organic chemical contaminants.		▲	
	Ohly, H., Gentry, S., Wigglesworth, R., Bethel, A., Lovell, R., & Garside, R. (2016). A systematic review of the health and well-being impacts of school gardening: synthesis of quantitative and qualitative evidence. BMC Public Health, 16(1), 286.	https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-016-2941-0	Systematic review finding some evidence of benefits to a number of health and behavioural outcomes resulting from participation in school gardening activities.		▲	
GI/ESS disservices and health	von Döhren, P., & Haase, D. (2015). Ecosystem disservices research: a review of the state of the art with a focus on cities. Ecological Indicators, 52, 490-497.	https://www.sciencedirect.com/science/article/pii/S1470160X14006037	Literature review finding some evidence of urban ecosystem disbenefits to health through pathways such as increased allergenic compounds, vector spread disease, increased feelings of anxiety and reduced quality of life through animal and plant litter, feelings of insecurity and fear caused by dense urban greenspaces.		▲	
	Osborne, N.J., Alcock, I., Wheeler, B.W., Hajat, S., Sarran, C., Clewlow, Y., McInnes, R.N., Hemming, D., White, M., Vardoulakis, S., Fleming, L.E., (2017). Pollen exposure and hospitalization due to asthma exacerbations: daily time series in a European city. International Journal of Biometeorology, 1-12.	https://link.springer.com/article/10.1007/s00484-017-1369-2	Empirical time series study of pollen concentrations and hospital admissions for asthma in London. Higher grass pollen days associated with increased asthma admissions with a 4-5 day lag. Tree pollen results inconclusive.	●		
	Lõhmus, M., & Balbus, J. (2015). Making green infrastructure healthier infrastructure. Infection ecology & epidemiology, 5, 30082-30082. doi: 10.3402/iee.v5.30082	https://www.ncbi.nlm.nih.gov/pubmed/26615823	Literature review highlighting potential disbenefits of urban green infrastructure include providing habitats for vector or host organisms for infectious pathogens leading to the spread of a variety of diseases, water and wetlands providing habitats for mosquitoes and toxic algal blooms, and the enhanced exposure to pollen and other allergenic matter.		▲	
Type, amount, proximity, and quality of GI and health outcomes	Dinand Ekkel, E. and S. de Vries (2017). Nearby green space and human health: Evaluating	https://www.sciencedirect.com/science/article/pii/S0169204616301153	Evidence review finding that that indicators of cumulative opportunities (e.g. neghbourhood greenspace area density) are more consistently	●		

2.C. Evidence Topic	Title	Source	Annotation	Primary Evidence	Secondary Evidence	Tertiary Evidence
	accessibility metrics. Landscape and Urban Planning 157: 214-220.		positively related to health than residential proximity indicators.			
	Browning, M. and K. Lee (2017). Within What Distance Does Greenness Best Predict Physical Health? A Systematic Review of Articles with GIS Buffer Analyses across the Lifespan. Int J Environ Res Public Health 14(7).	https://www.ncbi.nlm.nih.gov/pubmed/28644420	Systematic review finding that using larger buffers (up to 2000m) to capture exposure to greenspace around the home residence better predicted physical health than smaller buffers.		△	
	Schipperijn, J., P. Bentsen, J. Troelsen, M. Toftager and U. K. Stigsdotter (2013). Associations between physical activity and characteristics of urban green space. Urban Forestry & Urban Greening 12(1): 109-116.	https://www.sciencedirect.com/science/article/pii/S1618866712001197	Primary analysis of Dutch data found no association between outdoor physical activity in general and the size of, distance to, and number of features in the nearest urban greenspace, nor with the amount and number of urban greenspaces within 1km. Some associations between reported physical activity in specific urban greenspaces and the size, presence of walking/cycling routes, wooded areas, water features, lights, pleasant views, bike rack, and parking lot in the nearest urban greenspaces was found.	●		
	Roy, S., Byrne, J., & Pickering, C. (2012). A systematic quantitative review of urban tree benefits, costs, and assessment methods across cities in different climatic zones. Urban Forestry & Urban Greening, 11(4), 351-363.	https://www.sciencedirect.com/science/article/pii/S1618866712000829	Systematic review finding that urban street trees are associated with both positive and negative impacts to health outcomes.		△	
	Wheeler, B., Lovell, R., Higgins, S., White, M., Alcock, I., Osborne, et al. (2015). Beyond greenspace: an ecological study of population general health and indicators of natural environment type and quality. International Journal of Health Geographics, 14(1), 17.	http://www.ij-healthgeographics.com/content/14/1/17	Primary analysis of Census (GB) and environmental data findings positive associations were observed between good health prevalence and the density of the greenspace types, broadleaf woodland , arable and horticulture , improved grassland , saltwater and coastal , after adjusting for potential confounders.	●		
	Salmond, J. A., Tadaki, M., Vardoulakis, S., Arbuthnott, K., Coutts, A., Demuzere, M., ... & McInnes, R. N. (2016). Health and climate related ecosystem services provided by street trees in the urban environment. Environmental Health, 15(1), S36.	https://ehjournal.biomedcentral.com/articles/10.1186/s12940-016-0103-6	Literature review finding some evidence clarifying how street trees relate to health outcomes through air pollution mitigation and exacerbation, noise attenuation and masking, emission of biogenic volatile compounds and through socio-cultural pathways.		△	
	Lovell, R., Wheeler, B. W., Higgins, S. L., Irvine, K. N., & Depledge, M. H. (2014). A systematic review of the health and well-being benefits of biodiverse environments. Journal of Toxicology and Environmental Health, Part B, 17(1), 1-20.	https://www.tandfonline.com/doi/abs/10.1080/10937404.2013.856361	Systematic review finding limited evidence that more biodiverse environments are associated with more favourable health and wellbeing outcomes.		△	
	P Horwitz, C Kretsch, A Jenkins, A Rahim, A Burls, K Campbell, M Carter, … (2015) Contribution of biodiversity and green spaces to mental and	https://ore.exeter.ac.uk/repository/handle/10871/19908	A literature review finding some evidence of multiple benefits of biodiverse natural environments to health		△	

2.C. Evidence Topic	Title	Source	Annotation	Primary Evidence	Secondary Evidence	Tertiary Evidence
	physical fitness, and cultural dimensions of health in. Connecting Global Priorities: Biodiversity and Human Health, 200-219		through physical activity, wellbeing, quality of life and cultural pathways.			
	Sandifer, P. A., Sutton-Grier, A. E., & Ward, B. P. (2015). Exploring connections among nature, biodiversity, ecosystem services, and human health and well-being: Opportunities to enhance health and biodiversity conservation. Ecosystem Services, 12, 1-15.	https://www.sciencedirect.com/science/article/pii/S2212041614001648	Evidence review finding some evidence that biodiversity (including microbial diversity) is associated with certain health outcomes.		△	
	Aerts, R., O. Honnay and A. Van Nieuwenhuyse (2018). Biodiversity and human health: mechanisms and evidence of the positive health effects of diversity in nature and green spaces. British Medical Bulletin 127(1): 5-22.	https://academic.oup.com/bmb/article/127/1/5/5051732	Evidence review finding some evidence of positive associations between species diversity and well-being (psychological and physical) and between ecosystem diversity and immune system regulation.		▲	
Physical (e.g. built, environment restoration etc.) interventions	Roberts, H., McEachan, R., Margary, T., Conner, M., & Kellar, I. (2018). Identifying effective behavior change techniques in built environment interventions to increase use of green space: a systematic review. Environment and Behavior, 50(1), 28-55.	https://journals.sagepub.com/doi/10.1177/0013916516681391	Systematic review finding that 'restructuring the physical environment' in combination with 'adding objects to the environment,' encouraged increased use of greenspaces. Adding a 'prompt or cue' alongside changes to the environment also appeared to be effective.		△	
	World Health Organization. (2017) Urban Green Space Interventions and Health: A review of impacts and effectiveness. Copenhagen	http://www.euro.who.int/en/health-topics/environment-and-health/urban-health/publications/2017/urban-green-space-interventions-and-health-a-review-of-impacts-and-effectiveness.-full-report-2017	Evidence reviews which found that interventions to increase or improve urban greenspace are associated with a range of health, social and environmental outcomes, particularly among lower socioeconomic status groups. Combined approaches of modifications to the natural/built environment coupled with social interventions were most effective.		▲	
	Moore, T. H. M., Kesten, J. M., López-López, J. A., Ijaz, S., McAleenan, A., Richards, A., ... & Audrey, S. (2018). The effects of changes to the built environment on the mental health and well-being of adults: Systematic review. Health & place, 53, 237-257.	https://www.sciencedirect.com/science/article/pii/S1353829217308869	Systematic review of randomised (or cluster randomised) controlled trials and controlled before-and-after studies of changes to the built environment found no evidence of positive effect on mental health from 'urban regeneration' and 'improving green infrastructure', some limited evidence of effect to quality of life and social isolation outcomes from 'improving green infrastructure'.		▲	
	South, E. C., Hohl, B. C., Kondo, M. C., MacDonald, J. M., & Branas, C. C. (2018). Effect of greening vacant land on mental health of community-dwelling adults: a cluster randomized trial. JAMA network open, 1(3), e180298-e180298.	https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2688343	Primary cluster randomized trial found communities (Philadelphia, US) esposed to a greening intervention compared to communities with no intervention demonstrated a significant decrease in feelings of being depressed and worthlessness, and a as a nonsignificant reduction in overall self-reported poor mental health.	●		

2.C. Evidence Topic	Title	Source	Annotation	Primary Evidence	Secondary Evidence	Tertiary Evidence
	Droomers, M., et al. (2015). The impact of intervening in green space in Dutch deprived neighbourhoods on physical activity and general health: results from the quasi-experimental URBAN40 study. Journal of Epidemiology and Community Health.	http://jech.bmj.com/content/early/2015/08/21/jech-2014-205210.abstract	Primary quasi-experimental study found that changes to the quality or quantity of green space in severely deprived Dutch neighbourhoods resulted in no identifiable favourable change to trends of physical activity and good general health compared to control areas.	●		
Social interventions and green prescriptions	World Health Organization. (2017) Urban Green Space Interventions and Health: A review of impacts and effectiveness. Copenhagen	http://www.euro.who.int/en/health-topics/environment-and-health/urban-health/publications/2017/urban-green-space-interventions-and-health-a-review-of-impacts-and-effectiveness.-full-report-2017	Evidence reviews which found that interventions to increase or improve urban greenspace are associated with a range of health, social and environmental outcomes, particularly among lower socioeconomic status groups. Combined approaches of modifications to the natural/built environment coupled with social interventions were most effective.		▲	
	Annerstedt, M. and P. Wahrborg (2011). Nature-assisted therapy: systematic review of controlled and observational studies. Scandinavian Journal of Public Health 39(4): 371-388.	https://www.ncbi.nlm.nih.gov/pubmed/21273226	Systematic review finding that there is some evidence that 'nature-assisted therapy' has some positive impacts to health and wellbeing outcomes.		△	
	Lovell, R., K. Husk, C. Cooper, W. Stahl-Timmins and R. Garside (2015). Understanding how environmental enhancement and conservation activities may benefit health and wellbeing: a systematic review. BMC Public Health 15(1): 864.	https://www.ncbi.nlm.nih.gov/pubmed/26346542	Systematic review finding some evidence of positive impacts of conservation volunteering (including in urban greenspaces) on improved wellbeing and quality of life.		△	
	Hanson, S. and A. Jones (2015) Is there evidence that walking groups have health benefits? A systematic review and meta-analysis. British Journal of Sports Medicine 49(11): 710-715.	https://bjsm.bmj.com/content/49/11/710	Systematic review and meta-analysis showing that participation in walking groups is associated with several positive health outcomes including reductions in blood pressure, resting heart rate, body fat and total cholesterol.		△	
	Roberts, H., McEachan, R., Margary, T., Conner, M., & Kellar, I. (2018). Identifying effective behavior change techniques in built environment interventions to increase use of green space: a systematic review. Environment and Behavior, 50(1), 28-55.	https://journals.sagepub.com/doi/10.1177/0013916516681391	Systematic review finding that 'restructuring the physical environment' in combination with 'adding objects to the environment,' encouraged increased use of greenspaces. Adding a 'prompt or cue' alongside changes to the environment also appeared to be effective.		△	
	Britton, E., Kindermann, G., Domegan, C., & Carlin, C. (2018). Blue care: a systematic review of blue space interventions for health and wellbeing. Health Promotion International.	https://academic.oup.com/heapro/advance-article/doi/10.1093/heapro/day103/5252008	Systematic review finding that 'blue care interventions' are associated with some positive health gain, including to mental health and psycho-social wellbeing.		△	
Pupil mental health, wellbeing and psychological	Becker, C., G. Lauterbach, S. Spengler, U. Dettweiler and F. Mess (2017). Effects of regular classes in outdoor education settings: a systematic review on students' learning, social and health dimensions. International journal of environmental research and public health 14(5): 485.	https://www.ncbi.nlm.nih.gov/pubmed/28475167	Systematic review finding very limited evidence of a positive impact to mental health resulting from participation in outdoor learning activities.		▲	

2.C. Evidence Topic	Title	Source	Annotation	Primary Evidence	Secondary Evidence	Tertiary Evidence
	Educational Endowment Foundation and Sutton Trust (undated). Outdoor adventure learning. Teaching and learning toolkit.	https://educationendowmentfoundation.org.uk/evidence-summaries/teaching-learning-toolkit	Literature review finding some evidence of a positive impact of outdoor learning on self-confidence of students, with greater impacts for more vulnerable students and older learners.		▲	
	Wallner, P., M. Kundi, A. Arnberger, R. Eder, B. Allex, L. Weitensfelder and H.-P. Hutter (2018). Reloading Pupils' Batteries: Impact of Green Spaces on Cognition and Wellbeing. International Journal of Environmental Research and Public Health 15(6): 1205.	https://www.ncbi.nlm.nih.gov/pubmed/29890637	Primary analysis of Austrian data finding positive associtions between surrounding greenness and academic performance in English and Maths.	●		
	Ohly, H., S. Gentry, R. Wigglesworth, A. Bethel, R. Lovell and R. Garside (2016). A systematic review of the health and well-being impacts of school gardening: synthesis of quantitative and qualitative evidence. BMC Public Health 16(1): 1-36.	https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-016-2941-0	Systematic review finding some evidence of benefits to a number of mental health outcomes in participants.		▲	
	van Dijk-Wesselius JE, Maas J, Hovinga D, van Vugt M, van den Berg AE. (2018) The impact of greening schoolyards on the appreciation, and physical, cognitive and social-emotional well-being of schoolchildren: A prospective intervention study. Landscape and Urban Planning. 180:15-26.	https://www.sciencedirect.com/science/article/pii/S0169204618307369?via%3Dihub	Primary longitudinal prospective intervention study found the greening of Dutch school yards was associated with higher social wellbeing in comparison to schools that had not been greened, no effect on emotional well-being was found.	●		
Scientific and Educational outcomes	Rickinson, M., J. Dillon, K. Teamey, M. Morris, M. Young Choi, D. Sanders and P. Benefield (2004). A review of research on outdoor learning. London, National Foundation for Educational Research and King's College London.	https://kclpure.kcl.ac.uk/portal/en/publications/a-review-of-research-on-outdoor-learning(18eca605-d43c-42f9-a3ab-fee4225f7c95)/export.html	Literature review finding some evidence of positive impacts to outcomes such as science process skills and improved understanding of design and technology-related concepts.		▲	
	Fiennes C, Oliver E, Dickson K, Escobar D, Romans A, Oliver S. (2015) The Existing Evidence-Base about the Effectiveness of Outdoor Learning. UCL; Giving Evidence; IOL; Blagrave Trust	https://www.lotc.org.uk/the-existing-evidence-base-about-the-effectiveness-of-outdoor-learning/	Review finding some evidence of the positive outcomes of learning outside the classroom on educational outcomes		▲	
Cognitive performance, attainment of skills and academic performance	Educational Endowment Foundation and Sutton Trust (undated). Outdoor adventure learning. Teaching and learning toolkit.	https://educationendowmentfoundation.org.uk/evidence-summaries/teaching-learning-toolkit	Literature review consistent positive benefits of outdoor learning on academic performance with greater impacts for more vulnerable students and older learners.		▲	
	Fiennes C, Oliver E, Dickson K, Escobar D, Romans A, Oliver S. (2015) The Existing Evidence-Base about the Effectiveness of Outdoor Learning. UCL; Giving Evidence; IOL; Blagrave Trust 2015.	https://www.lotc.org.uk/the-existing-evidence-base-about-the-effectiveness-of-outdoor-learning/	Review finding some evidence of the positive outcomes of learning outside the classroom on academic skills and attitudes towards education.		▲	
	Becker, C., G. Lauterbach, S. Spengler, U. Dettweiler and F. Mess (2017). Effects of regular classes in outdoor education settings: a systematic review on students' learning, social and health	https://www.ncbi.nlm.nih.gov/pubmed/28475167	Systematic review finding limited evidence of positive impacts to educational and academic outcomes following participation in a range of outdoor learning activities.		▲	

2.C. Evidence Topic	Title	Source	Annotation	Primary Evidence	Secondary Evidence	Tertiary Evidence
	dimensions. International journal of environmental research and public health 14(5): 485.					
	Ohly, H., S. Gentry, R. Wigglesworth, A. Bethel, R. Lovell and R. Garside (2016). A systematic review of the health and well-being impacts of school gardening: synthesis of quantitative and qualitative evidence. BMC Public Health 16(1): 1-36.	https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-016-2941-0	Systematic review finding some evidence of benefits to a number of educational outcomes resulting from participation in school gardening activities, pupils who found classroom-based learning challenging were thought to particularly benefit.		▲	
	Dadvand, P., M. J. Nieuwenhuijsen, M. Esnaola, J. Forns, X. Basagaña, M. Alvarez-Pedrerol, I. Rivas, M. López-Vicente, M. De Castro Pascual, J. Su, M. Jerrett, X. Querol and J. Sunyer (2015). Green spaces and cognitive development in primary schoolchildren. Proceedings of the National Academy of Sciences 112(26): 7937-7942.	https://www.pnas.org/content/112/26/7937	Primary analysis of Spanish data found an association between total greenness at home, school, and along commuting routes and cognitive development.	●		
	Tuen Veronica Leung, W., T. Yee Tiffany Tam, W.-C. Pan, C.-D. Wu, S.-C. Candice Lung and J. D. Spengler (2019). How is environmental greenness related to students' academic performance in English and Mathematics? Landscape and Urban Planning 181: 118-124.	https://www.sciencedirect.com/science/article/pii/S0169204618310569	Primary analysis of US data finding positive associations between surrounding greenness and academic performance in English and Maths.	●		
	Kuo, M., M. H. Browning, S. Sachdeva, K. Lee and L. Westphal (2018). Might school performance grow on trees? Examining the link between greenness and academic achievement in urban, high-poverty schools. Frontiers in Psychology 9(109).	https://www.frontiersin.org/articles/10.3389/fpsyg.2018.01669/full	Primary analysis of US data finding that the greenness of the school environment was associated with maths outcomes.	●		
	Matsuoka, R. H. (2010). Student performance and high school landscapes: Examining the links. Landscape and Urban Planning 97(4): 273-282.	https://www.sciencedirect.com/science/article/pii/S0169204610001465	Primary analysis of US data found that school room views with greater quantities of trees and shrubs were positively associated with higher standardized test scores and graduation rates.	●		
Motivations to learn, enjoyment of learning and teaching	Rickinson, M., J. Dillon, K. Teamey, M. Morris, M. Young Choi, D. Sanders and P. Benefield (2004). A review of research on outdoor learning. London, National Foundation for Educational Research and King's College London.	https://kclpure.kcl.ac.uk/portal/en/publications/a-review-of-research-on-outdoor-learning(18eca605-d43c-42f9-a3ab-fee4225f7c95)/export.html	Literature review finding some evidence of positive impacts to outcomes such as stronger motivation toward learning and student-teacher relationships.		▲	
	Becker, C., G. Lauterbach, S. Spengler, U. Dettweiler and F. Mess (2017). Effects of regular classes in outdoor education settings: a systematic review on students' learning, social and health dimensions. International journal of environmental research and public health 14(5): 485.	https://www.ncbi.nlm.nih.gov/pubmed/28475167	Systematic review finding limited evidence of positive impacts to educational and academic outcomes following participation in a range of outdoor learning activities.		▲	

2.C. Evidence Topic	Title	Source	Annotation	Primary Evidence	Secondary Evidence	Tertiary Evidence
	Dettweiler, U., G. Lauterbach, C. Becker and P. Simon (2017). A Bayesian Mixed-Methods Analysis of Basic Psychological Needs Satisfaction through Outdoor Learning and Its Influence on Motivational Behavior in Science Class. Frontiers in Psychology 8(2235).	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5742242/	Primary study found that German student's motivations to learn were positively impacted by outdoor learning experiences.	●		
Improved concentration and behaviour	Matsuoka, R. H. (2010). Student performance and high school landscapes: Examining the links. Landscape and Urban Planning 97(4): 273-282.	https://www.sciencedirect.com/science/article/pii/S0169204610001465	Primary analysis of US data found that schoool room views with greater quantities of trees and shrubs were positively associated with improved student behaviours including fewer occurrences of criminal behaviour.	●		
	Fiennes C, Oliver E, Dickson K, Escobar D, Romans A, Oliver S. (2015) The Existing Evidence-Base about the Effectiveness of Outdoor Learning. UCL; Giving Evidence; IOL; Blagrave Trust 2015.	https://www.lotc.org.uk/the-existing-evidence-base-about-the-effectiveness-of-outdoor-learning/	Review finding some evidence of the positive outcomes of learning outside the classroom on behavioural outcomes.		▲	
	Kuo, M., M. H. E. M. Browning and M. L. Penner (2018). Do Lessons in Nature Boost Subsequent Classroom Engagement? Refuelling Students in Flight. Frontiers in Psychology 8(2253).	https://www.frontiersin.org/articles/10.3389/fpsyg.2017.02253/full	Primary study (US) found pupil behaviours were significantly better after lessons in nature in comparison to that following other types of learning experience.	●		
	van Dijk-Wesselius JE, Maas J, Hovinga D, van Vugt M, van den Berg AE. (2018) The impact of greening schoolyards on the appreciation, and physical, cognitive and social-emotional well-being of schoolchildren: A prospective intervention study. Landscape and Urban Planning. 180:15-26.	https://www.sciencedirect.com/science/article/pii/S0169204618307369?via%3Dihub	Primary longitudinal prospective intervention study found the greening of Dutch school yards was associated with more positive attentional restoration after recess in comparison to schools that had not been greened.	●		
Physical activity	Arbogast, K. L., B. C. P. Kane, J. L. Kirwan and B. R. Hertel (2009). Vegetation and outdoor recess time at elementary schools: What are the connections? Journal of Environmental Psychology 29(4): 450-456.	https://www.sciencedirect.com/science/article/pii/S0272494409000255	Primary study found higher amounts of school ground vegetation correlated positively with time spent outdoors during break times in schools in Virgina, US.	●		
	Romar, J.-E., I. Enqvist, J. Kulmala, J. Kallio and T. Tammelin (2018). Physical activity and sedentary behaviour during outdoor learning and traditional indoor school days among Finnish primary school students. Journal of Adventure Education and Outdoor Learning: 1-15.	https://www.tandfonline.com/doi/abs/10.1080/14729679.2018.1488594	Primary Finnish comparative study found lower levels of sedentary and increases in light to moderate intensity physical activity children's physical activity on outdoor learning days in comparison to traditional school days.	●		
	Mårtensson, F., M. Jansson, M. Johansson, A. Raustorp, M. Kylin and C. Boldemann (2014). The role of greenery for physical activity play at school grounds. Urban Forestry & Urban Greening 13(1): 103-113.	https://www.sciencedirect.com/science/article/pii/S1618866713001003	Primary comparative study of the impact of greenery in school grounds on Swedish school children's physical activity found mixed effects with the spaces with a mix of built and green most used.	●		
	Wells NM, Myers BM, Henderson CR, Jr. (2014) School gardens and physical activity: a randomized controlled trial of low-income elementary schools. Prev Med. 69 Suppl 1:S27-33.	https://www.ncbi.nlm.nih.gov/pubmed/25456803	Primary controlled experimental study found a greater increase in the percentage of time spent in moderate and moderate-to-vigorous intensity of activity against baseline in the 6 US schools that	●		

2.C. Evidence Topic	Title	Source	Annotation	Primary Evidence	Secondary Evidence	Tertiary Evidence
			had been provided with gardens in comparison to the rates of activity in 6 schools with no new garden.			
	van Dijk-Wesselius JE, Maas J, Hovinga D, van Vugt M, van den Berg AE. (2018) The impact of greening schoolyards on the appreciation, and physical, cognitive and social-emotional well-being of schoolchildren: A prospective intervention study. Landscape and Urban Planning. 180:15-26.	https://www.sciencedirect.com/science/article/pii/S0169204618307369?via%3Dihub	Primary longitudinal prospective intervention study found the greening of Dutch school yards was associated with higher rates of physical activity for amongst girls in comparison to rates in schools that had not been greened.	●		

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