

## **Annex 2: Evidence review and synthesis informing logic models**

### **1. Introduction**

This Annex outlines the evidence which has informed the development of two logic models. The first focuses on greenspace and the relationship between such spaces and health (broadly defined to include physical health, mental health, wellbeing and social health). The second logic model outlines the relationship between activities in greenspaces and health broadly defined. Both models were developed in the light of the literature, discussions with key informants and workshop discussions. In this way, this Annex provides an overview of the evidence base which underpins the Strategic Framework.

By the very nature of the topic - the relationship between greenspace and health broadly defined – much of the current evidence is that of association or involves evaluations of small-scale projects. Evidence of association, while considered a good first step when thinking about possible health outcomes, is not proof of cause and effect. Thus, for instance, in periods of hot sunny weather, sales of ice cream can rise as can the incidence of sunburn – a statistical association could be demonstrated between the two, but this does not mean that ice cream causes sunburn.

Some experimental evidence of relationships between greenspaces and health and wellbeing is available, often as a result of evaluations of specific interventions, but the “gold standard” of health evidence - the large scale double blind randomised controlled trial - is not possible when exploring such relationships. The evidence does, however, provide useful insights and suggests directions of travel, both in terms of the design and maintenance of the greenspace itself and the likely impact of different activities within such greenspaces and on different population groups.

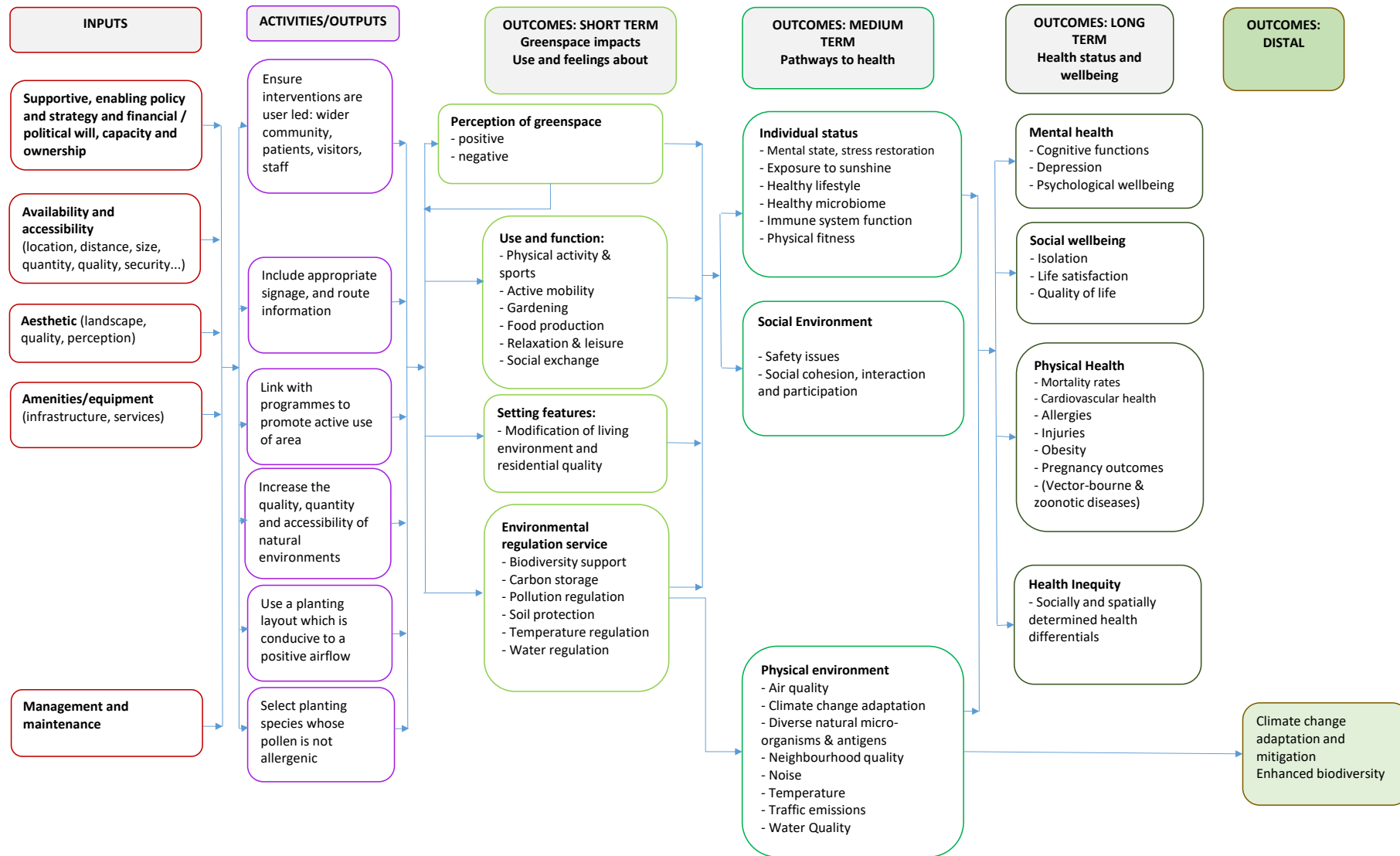
Much of the evidence looks at the relationship between the green-ness of the neighbourhoods in which people live and their health and wellbeing. This is of particular relevance when considering the NHS estate as part of the wider neighbourhood of local housing, and is of importance when considering access to the estate by local residents. There is a smaller evidence base which focusses on therapies and activities specifically in green and natural spaces.

This synthesis brings together the findings of a small number of recent reviews and is presented under the headings of the logic models (Figures 1 and 3). The logic model in Figure 1 was developed from a diagram in the 2017 World Health Organisation (WHO) Brief for Action (1) which in turn was a development of a diagram by Roue-le Gall in Milvoy-Le Gall (2015) – reference cited in the WHO report. The logic model has been further developed and refined in the light of evidence from:

- 2016 evidence report on this theme published by the WHO (2)
- 2017 evidence statement on the links between natural environments and health prepared by the University of Exeter for the UK Department for Rural Affairs (DEFRA) (3)
- 2017 report by a European Union funded project (INHERIT) which includes a chapter on greenspace and explores evidence relating to triple win solutions which encourage behaviour change, protect the environment and promote health and equity (4)
- updated review of physical activity and the environment for National Institute of Health and Clinical Excellence (NICE) also published in 2017 (5)
- review of nature-based interventions for mental health care published in 2017 by Natural Health England (6)

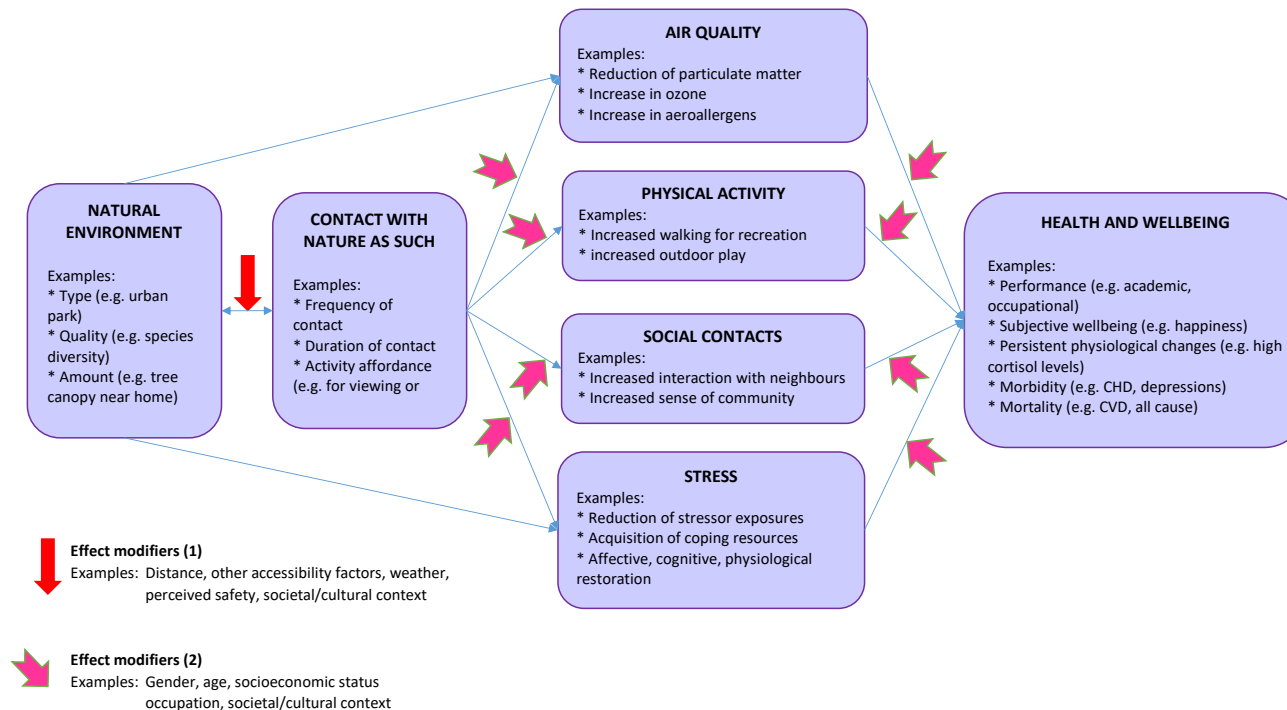
The logic model focusing on greenspace was further refined in the light of discussion with the steering group for the project in August 2018 and following the stakeholder workshop.

**FIGURE 1 Logic model: green environments and health and wellbeing**



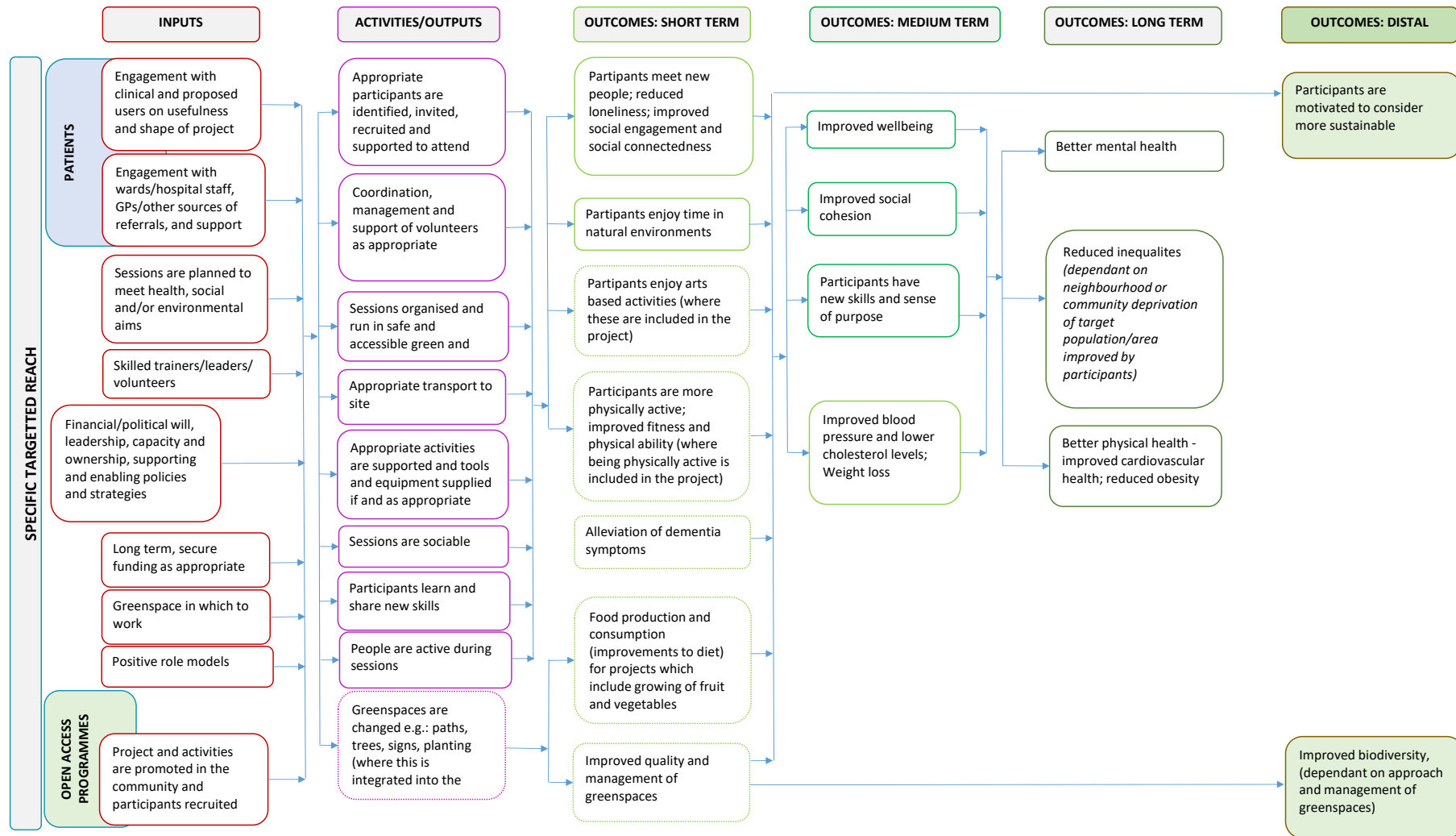
The INHERIT report (4) argued that contact with nature may affect both physical and mental health via multiple pathways and provided a model of how this may occur. Their diagram has been provided as Figure 2 below, as it gives a helpful insight into what they call “effect modifiers”. They reported that the areas which have received most research attention involve air quality, physical activity, social cohesion, and stress reduction and make an argument for more nuanced research on issues relating the type, quality and context of greenspace in relation to health and wellbeing. This report also discussed the importance of individual perception of greenspace to the final health and wellbeing outcomes.

**Figure 2 The INHERIT multiple pathways to health model (4)**



In the course of the surveys, interviews and workshops conducted within the project, a number of interventions were identified as being undertaken in the NHS estates within Lothian. These included projects which encouraged patients, staff and visitors into the grounds of the NHS estate, to undertake gardening/nature projects (e.g. therapeutic gardening, community gardening and allotments, branching out and green gyms) or simply to enjoy the contact with nature (e.g. sensory gardens and dementia gardens) or enjoy arts-based activities (e.g. branching out). Many of these have a focus on patients and visitors or on vulnerable members of the local community. In some cases, participants travel to the project sites. A second group of projects targeted people (local residents, staff or visitors) to encourage active travel through the estate or participation in health walks, and thus less sedentary behaviour. The logic model for these types of projects has been developed in the light of the evidence and of workshop discussions (Figure 3).

**Figure 3 Interventions targeting specific people to improve health or wellbeing**



*In the evidence sections below, explanatory notes have been provided in italics.*

## 2. Evidence: Elements of the greenspace and health logic model outlined in Figure 1

Note: In order to facilitate connection with the logic modes outlined above, headings and subheadings below are provided in the same colour as the box outlines of the logic models.

### 2.1 GREENSPACE LOGIC MODEL: DISTAL OUTCOMES

Distal outcomes describe possible impacts on global issues such as biodiversity, climate change and sustainable development. It is recognised that given the scale of the NHS estate, the impacts may be minimal, however thinking about such issues in the planning and maintenance of green spaces may provide a contribution to larger scale plans national commitments, policies and strategies.

#### Participants are motivated to consider more sustainable behaviours

The WHO report (2) suggested that exposure to the natural environment could increase cooperation, sustainable intentions and behaviour. The report went on to state that childhood experience of nature appear to enhance adult environmentalism (2).

#### Improved biodiversity (dependant on approach and management of the greenspace)

The level of biodiversity attained will depend on the planting and maintenance planning and implementation for any project. The mix and type of plants will influence biodiversity directly and also through their contribution to healthy wider ecosystems of organisms.

### 2.2 GREENSPACE LOGIC MODEL: LONG TERM OUTCOMES

#### Mental health

The evidence of links between experience of green or natural environments and mental health has variously been described as “*particularly strong*” (3) and “*substantial*” (4), and stronger than evidence for other potential pathways to health (2). The reports quoted evidence of links with stress (2, 3, 4); attentional fatigue (4); anxiety (3); and depression (3). It should be noted that there is a body of evidence in the wider literature linking chronic stress to a number of physical health outcomes such as inflammatory diseases, cardiovascular health and cancer.

Three of the reports (2, 3, 4) also quoted a small body of evidence linking contact with nature during childhood and cumulative benefits of significance in terms of the child’s development. Such contact may be positively associated with improved attention, concentration, impulse inhibition and mood across a range of socio-economic groups (2, 3, 4), some of which may be mediated by better air quality associated with greenspaces (2). There is evidence of association between greenspace contact and social networks and friendships across cultures, and the WHO report (2) suggests that natural environments may help to satisfy a child’s need for risky and adventurous behaviour (with a focus on adolescent males).

In older adults, there is evidence of associations between the quality of neighbourhood open spaces and walking behaviour and with mental health and wellbeing in this age group (4). There were studies which found that positive associations for people living in care homes with dementia between access to gardens, relaxation and memory stimulation (4).

### **Social wellbeing**

Three reviews considered social wellbeing and greenspace (2, 3, 4). They reported evidence of positive associations with: social networks (particularly for children and adolescents) (2); social cohesion (2, 4); social ties and sense of community in older people (4). Much of the evidence quoted comes from individual studies (2, 4). Negative associations have been found between the level of neighbourhood greenspace and reported loneliness – thus less greenspace associated with more loneliness (2, 4).

This is an area where individual perception of local greenspace was considered in terms of the quality of local greenspace (littering, other antisocial behaviour, feelings of safety) and social wellbeing (3, 4).

### **Physical health: mortality rates and cardiovascular health**

The evidence of associations between natural environments and a reduction of inflammatory based diseases has been described by the DEFRA report as “strong”, and it described the evidence of links with mortality as “generally positive” (3). While the DEFRA report described an “*extensive and robust*” body of evidence of an association between living in greener neighbourhoods and a reduced risk of mortality due to cardiovascular disease (3), the earlier WHO review considered the evidence base to be “*mixed*” and quoted a study which found an elevated risk of circulatory disease associated with living in such neighbourhoods (2). DEFRA quoted evidence of positive associations between living in greener neighbourhoods and favourable heart rate, blood pressure, levels of vitamin D and cortisol levels and went on to suggest living in greener neighbourhoods may be associated with lower levels of Type 2 diabetes (3). There may be a difference between men and women, with one UK study finding an association between reduced mortality rates from cardiovascular and respiratory disease and neighbourhood greenness for men but not women (3).

### **Physical health: allergies**

Studies have shown that exposure to diverse natural habitats may be important in the development of a healthy microbiome, which in turns plays a role in the development of a healthy immune system, and thus a reduction in levels of inflammatory based diseases such as asthma. The DEFRA report (3) describes this evidence as “particularly strong”. However, the WHO report (2) describes the evidence of associations with asthma and allergies as “inconclusive”, reporting studies which found both positive and negative associations between neighbourhood greenness and the prevalence of allergies and asthma in children. The DEFRA report is the only one of those consulted which discussed the idea of the microbiome and the evidence of links between this, contact with natural environments and health (3). For a description of the meaning of “microbiome” and further discussion of the evidence see the subsection titled “Individual status: healthy microbiome, immune system function” in the medium term or intermediate outcomes section below.

### **Physical health: injuries**

It has been argued (4) that while physical activity in greenspaces may have positive benefits, it can also be associated with increased risk of accidents and injuries such as falls and drownings. In the UK there is evidence that A&E admissions are higher for children living in areas with more parks (2), however the risk of serious injury in playgrounds is small in the UK, possibly as a result of the widespread use of artificial surfaces which absorb impact in playgrounds (2).

### **Physical health: obesity**

Described as “mixed or unclear” (3), the evidence of associations between living in greener neighbourhoods and obesity levels, were typically weak with inconsistent and mixed findings found across studies (2, 3, 4). Relationships varied across factors such as age, socio-economic status and the measure of greenspace which had been used (3). The WHO report argued that using greenspace for growing food could influence levels of physical activity and social wellbeing and may encourage healthy diets, thus influencing obesity levels in those who actively participate (2).

### **Physical health: pregnancy outcomes**

There is evidence described as “consistent” (3) of positive associations between living in greener neighbourhoods and positive pregnancy outcomes in terms of birthweight (2, 3) and levels of preterm-birth, although in the UK, any such association may not hold for all population groups with exceptions being found in BME groups (2, 3). Differences have been attributed to differing perceptions and use of greenspace (2, 3) and to variations in the quality of local greenspaces in areas with a high level of BME residents (2).

### **Physical health: vector borne and zoonotic diseases**

Vector-borne diseases are those where the infection results from (for example) the bite of an insect or another type of arthropod. One of the best known of these is malaria, where the parasite which causes the disease is introduced to humans via the bite of an infected mosquito (currently not an issue in the UK). In the UK, the disease currently of most relevance is Lyme disease which results from the bite of an infected tick (with deer acting as part of the natural reservoir). Thus the risk of Lyme disease is highest where there are natural deer populations and ticks.

Zoonotic diseases are those which are normally infections of other animals and where humans are accidental hosts. The WHO report (2) listed two such diseases of importance in the UK with relevance to green and natural spaces: *Toxocara canis* and *Toxoplasma gondii*. Infection with the first occurs as a result of ingestion of dog faeces and this parasitic worm can cause serious illness and blindness in children in rare circumstances. Infection with the second occurs as a result of contact with cat faeces and is an issue when first such contact occurs during pregnancy when it can result in severe neurological damage to the unborn child (2).

### **Health inequity**

The report for DEFRA (3) describes the evidence of a relationship between the greenness of lived neighbourhoods and health inequalities as “strong”. Research in parts of the UK has found that health inequalities related to income deprivation are lowest in those living in the greenest neighbourhoods compared to those living in neighbourhoods with less greenspace (4). There is evidence from across Europe that people living in more deprived circumstances often have less access to public greenspace (4). The WHO report (2) quoted the idea that living in greener neighbourhoods may be “equigenic” with any health benefits of living in greener neighbourhoods being strongest in those living in otherwise more deprived circumstances or who were considered more vulnerable (2,3).

In one study, socio-economic differences in mental wellbeing was 40% narrower among those who reported good access to green or recreational areas compared to those with poorer access (3). While most of the studies reviewed for the DEFRA report (3) looked at short term outcomes, they found a growing body of evidence based on longitudinal studies and stronger study design, resulting in what they considered to be a more robust body of evidence. They also quoted evidence that associations with lower rates of stress, anxiety, fatigue and depression were most significant for marginalised groups (3).

The relationship between health and access to greenspace may be more subtle than a one size fits all. The DEFRA report (3) provided a helpful summary of differences between social and economic groups as follows:

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- with increasing levels of neighbourhood greenspace, a reduction in male mortality rates has been found (but not for females)
- in a European study, in suburban areas with lower income profiles, greener living environments were associated with worse perceived health status (the authors hypothesised that this may be the result of the greenspace in such areas being of poorer quality)
- in a longitudinal study of the British Panel Survey, there was variation between level of local greenspace and mental health by age/life stage and gender. In men, any benefit emerged in early- to mid-adulthood. In older women, a curvilinear relationship was found where those living in areas with a moderate level of greenspace availability reported better mental health

Several theories were quoted to account for such differences (3): variations in the quality of greenspaces; variations in the ways in which such greenspaces were used (both in terms of reasons for use and types of use); and differing social-cultural norms affecting the ways in which such greenspaces were perceived. There is some evidence that each of these may have played a role in influencing outcomes (3).

Women may be more fearful of going into greenspace than men (2) although this may vary by context. A study in a New York park, for instance, found that women felt safer exercising in the park than on local streets quoting less catcalls and harassment and a lack of traffic as well as the therapeutic and scenic qualities in their decision to use the park. The report for DEFRA (3) considered context important in these relationships quoting the importance of physical and psychological perceptions of accessibility and motivations for use between different population groups.

## 2.3 GREENSPACE LOGIC MODEL: MEDIUM TERM OUTCOMES – PATHWAYS TO HEALTH

### Individual status: mental state

According to the DEFRA report (3), there is “reliable evidence” of a relationship between contact with nature and improvements (from a health point of view) in emotional state, self-reported anger, fatigue, anxiety, sadness and feelings of an increase in energy. They described the evidence relating to a reduction in stress and attentional fatigue following contact with nature as being mainly based on short term measures.

There is evidence from a “small body of research” (3) of cumulative and far reaching developmental impacts for children following contact with nature – quoting evidence of improvements to attentional function in children with Attention Deficit Disorder, and self-discipline in those without such a diagnosis (3). Positive associations have been found with memory, attention, concentration, impulse inhibition and mood across a range of populations (3) and studies have found a link between greenery around schools and the cognitive development of pupils (3).

### Individual status: stress restoration

There is evidence of changes in psychological and physiological indicators of stress after time spent in green or woodland areas (compared to urban settings). These include improvements (in terms of health benefits) in levels of cortisol (2, 3), (but note gender differences here); pulse/heart rates (2, 3); blood pressure (3); para-sympathetic and sympathetic nerve activity (2); enhanced relaxation (2) and restoration (2); improvements in cognitive function (2); self-esteem (3) and mood (3).

A number of theories have been suggested to explain such changes. These include:

- less exposure to challenging stressors by screening annoying noise or displeasing structures and improving feelings of privacy (4);
- natural environments may provide “escape facilities” to some people which help them to restore their adaptive resources (4);



- a view of natural greenspace may allow those with high levels of stress to shift to a more positive mental state and thus feelings of enhanced wellbeing and relaxation (2);
- the involuntary attention people give to interesting and rich stimuli in natural environments may lead to improved performance of cognitively demanding tasks (thus providing attention restoration) (2).

### **Individual status: physical activity in greenspace and stress restoration**

There are suggestions that exercise in greenspaces may provide more benefits to health and wellbeing than exercise in other settings (such as indoors or on streets) (2, 4). There is evidence that recreational walking, an increase in physical activity levels and less time being sedentary have all been associated with access to and use of greenspace in working age adults, children and older adults (4). Some studies have found that running in a park is associated with a greater restorative experience than running in urban environments (2, 4). In a study in Scotland, regular exercise in natural environments was associated with a halving of the risk of poor mental health (3) and exercise in such areas has been associated with greater feelings of revitalisation and positive engagement; less tension, confusion, anger and depression; and more energy compared to indoor exercise (3).

### **Individual status: exposure to sunlight**

The INHERIT report (4) listed effects of increased exposure to sunlight if people spend more time in the out of doors in greenspaces. The impacts listed were both positive (increased production of Vitamin D (2, 4) and improved sleep patterns (2, 4)) and negative (sunburn and increased risk of skin cancer). The INHERIT report argued that this was of greatest importance to people living in Northern Europe where there is a lack of high levels of sunlight for significant parts of the year, and for older people whose ability to synthesise Vitamin D declines with age (4). That report quoted one study which found higher levels of Vitamin D in older people who engaged in outdoor activities especially cycling and gardening. The association between greenspace and reduced sleep deficiency has been found to be stronger in adults over the age of 65 years (2).

The WHO report (2) discussed the ideas that:

- exposure to ultraviolet light could result in the release of nitric oxide from the skin, lowering hypertension and cardiovascular disease (evidence from a single study)
- exposure to blue light may improve alertness cognition and promote healthy sleep, it may also improve metabolism and circadian rhythms which would also result in improved sleep patterns.

### **Individual status: healthy lifestyle**

*See notes on physical fitness (below), obesity (diet) (above) and exposure to sunlight (above).*

### **Individual status: healthy microbiome, immune system function**

Microbiome is a term used to describe the micro-organisms which inhabit all the surfaces of the body, including the lining of e.g. the digestive and respiratory systems. Studies have shown that exposure to diverse natural environments may be critical in the development of a healthy microbiome, which it is argued, is in turn important for the development of a healthy immune system and thus less inflammatory disease such as asthma (3). The DEFRA study described the evidence of such links as “particularly strong”.

Positive associations have been found in Japan between visiting forests and immune systems including the expression of anti-cancer proteins (2). Such associations may arise through relaxation afforded by contact with natural environments (2); contact with physical or chemical factors found in greenspace (2); or exposure to diverse natural organisms which may play an immune-regulatory role (2).

### **Individual status: physical fitness**

The evidence relating physical activity and access to greenspace is not simple, with a large number of contextual issues impacting on any such relationship, resulting in variation between subgroups within populations (2). In addition, people can be physically active for a number of reasons, summarised by the INHERIT report as work, active transport and leisure (4). The DEFRA report concluded that generally positive associations have been found concerning physical activity levels in selected groups (3) but indicated that no causality had been proved, describing the evidence base as “mixed or unclear”. The NICE review (5) found interventions in parks showed mixed effects on park visits and physical activity expenditure, and suggest that this may be the result of factors outside of the scope of interventions affecting outcomes.

There is evidence of association between the quality of open spaces in neighbourhoods and walking levels in older people (4).

### **Social environment: safety issues**

The NICE review (5) found evidence that poor perception of safety (in terms of personal security) appeared to be a significant deterrent to using existing or new parks and trails. While interventions tended to result in improved feelings of safety, it did not always follow that there was an increased use of park or trails or an increase in physical activity levels.

Conversely, where green or open spaces are considered to be unsafe or where others are engaging in antisocial behaviour, this could have negative impacts on social cohesion (4). These can be addressed through appropriate management and maintenance (4).

### **Social environment: social cohesion, interaction and participation**

The evidence of a relationship between green and natural spaces and social contact and community cohesion has been described as “generally positive links” coming largely from mixed evidence sources, individual journal articles and sources which have not been peer reviewed (3). Associations have been found between the perceived greenness of a neighbourhood and both social interaction and social coherence (3, 4). Conversely, there is some evidence that residents in areas with less greenspace report more loneliness and a shortage of social support (2, 3, 4). Residents in areas with more grass and trees have displayed less aggressive behaviour and experienced lower crime levels (3). It has also been argued that exposure to natural environments may increase community cooperation when considering environmental problems, and motivations for community activity (2, 3). Experience of nature in childhood can be associated with enhanced levels of environmentalism in adults (2).

### **Physical environment: air quality**

It has been argued that green infrastructure can promote emissions reductions through behaviour change (encouraging or enabling people to switch to active modes of transport (but see above)) and that air quality can be significantly better in greenspaces than in surrounding urban areas (4), as a result of the effects of some forms of vegetation reducing gas and particulate pollutants (3), it has been suggested that the microenvironments engendered by vegetation can generate airflows which disperse pollutants (4). Positive impacts on air quality may be offset by the production of hydrocarbons by the vegetation (3) and the release of pollens which can exacerbate allergies (3).

### **Physical environment: climate change adaptation**

In a list of co-benefits of urban greenspaces, the WHO report (2) included enhanced hydrological systems and sustainable urban drainage, thus preventing and mitigating flooding.

### **Physical environment: diverse and natural microorganisms and antigens**

In a list of co-benefits of urban greenspaces, the WHO report (2) included the idea that these could provide biodiversity hotspots (4). While it has been argued that the global loss of biodiversity could impact on health in the long term (3), the current evidence linking ecological quality and health is limited (3) with inconsistent associations being found between ecological quality and mainly mental health and wellbeing outcomes (3).

### **Physical environment: neighbourhood quality**

The WHO list of co-benefits of urban greenspaces includes the idea that such greenspaces impact on local property values, and attract new residents and investment (2).

### **Physical environment: noise**

Well-designed urban greenspace can buffer noise or negative perceptions of noise (by masking e.g. traffic noise) and thus provide some relief from city noise (2, 4). It has been argued that some of the attenuation of such noise by belts of vegetation may be psychological (2,4).

### **Physical environment: temperature**

Vegetation can help to mitigate the urban “heat island” effect (4), the average cooling impact of a park is 1 degree centigrade with an effect up to 1 km, and greater effects observed if the park includes a body of water (2).

### **Physical environment: traffic emissions**

*If changes to the environment lead to an increase in more active forms of travel (walking or cycling) and a reduction in use of private transport, this would lead to a reduction in traffic emissions.*

### **Physical environment: water quality**

*If there is a reduction in the level of hard landscaping, the land would be more able to absorb the effects of heavy rainfall, resulting in less flooding downstream and less risk of sewage overflow.*

## 2.4 GREENSPACE LOGIC MODEL: SHORT TERM OR EARLY OUTCOMES – GREENSPACE IMPACTS, USE AND FEELINGS ABOUT

### Individual perception of an area of greenspace

Individual perception is an important mediator of any relationship between contact with/experience of greenspace and health and wellbeing (4, 5). Poor perceptions of safety can act as a significant deterrent to use (5), even when such perceptions are not reflected in crime statistics (2). The groups who felt most at risk were older people, women and ethnic minorities (2).

### Use and function: physical activity and sports

The NICE review (5), using the evidence quality criteria generally accepted for clinical medicine, described evidence of a relationship between access to greenspace and physical activity levels as “poor” (5). The DEFRA report (3) described the evidence as showing “generally positive associations” in selected groups, but indicated that no causality had been proved, citing methodological problems in identifying the direction of causality – do people choose to live in greener areas because they like walking and cycling or does the experience of living in such areas encourage walking and cycling (or is it a mixture of both)? There is some evidence that woodlands, gardens, parks, grassland and farmland may be supportive of vigorous activity (3).

### Use and function: active mobility

Recreational walking, increased physical activity and lower levels of time spent being sedentary have all been associated with access to and use of greenspace in working age adults, children and senior citizens (4). There is evidence of differential relationships between differing population groups (2) and between walking for transport and for leisure (2, 5).

### Use and function: gardening

It has been argued that community gardening can contribute to health and neighbourhood quality as well as local food production and consumption (4). Gardening may benefit health through stress reduction, contributing to levels of physical activity, increased consumption of fruit and vegetables, and more social contact, particularly in the elderly (4). However, evidence of association may over-estimate any outcomes for the wider population as the people who participate in such community gardening may be attracted to participate due to their enjoyment of gardening and healthy foods or because they are seeking social contact (4).

### Use and function: food production

There is some evidence (2) that using greenspace for growing food may contribute to levels of physical activity and social wellbeing and encourage a healthy diet (by consumption of fruit and vegetables grown).

### Use and function: relaxation and leisure

*One of the pathways by which contact with greenspace may result in improvements to mental health and wellbeing is that of using such areas as “escape facilities” in which they can relax.* The report for DEFRA also suggested that benefits from conservation activities may be via exposure to natural environments and enjoyment (3).

### Use and function: social exchange

There is evidence of positive relationships between social contact and community cohesion and natural environments (3).

### **Setting features: modification of living environments and residential quality**

*The quality and quantity of greenspace in a neighbourhood may contribute to the perceived quality and attractiveness of that neighbourhood.*

### **Environmental regulation services: biodiversity support**

The DEFRA report (3) argued that biodiversity is crucial to underpin the healthy functioning of ecosystems which in turn deliver goods and services which support human health and wellbeing. The level of biodiversity supported depends on the planting, maintenance and connectivity of individual greenspaces.

### **Environmental regulation services: carbon storage**

*Depending on the planting and maintenance of the area.*

### **Environmental regulation services: pollution regulation**

Some types of vegetation including some trees may reduce levels of air pollutants (gases and particulate matter) (3). The overall impact of vegetation is the result of several processes which can act in different directions: hydrocarbon and pollen production in one direction; pollutant uptake and impacts on energy demand in another (3, 4).

### **Environmental regulation services: soil protection**

*Depending on the planting, hard and soft infrastructure, maintenance and use of the area.*

### **Environmental regulation services: temperature regulation**

Vegetation can help to mitigate the urban “heat island” effect (4), the average cooling impact of a park is 1 degree centigrade with an effect up to 1 km, and greater effects observed if the park includes a body of water (2).

### **Environmental regulation services: water regulation**

Upstream processes such as water retention in upland peat avoids downstream flooding, thus impacting on water quality and the health of downstream communities (3).

## **2.5 GREENSPACE LOGIC MODEL: ACTIVITIES/OUTPUTS**

### **Ensure interventions are user led**

It has been argued (3, 4) that involving local people in the design and maintenance of greenspaces may result in areas which are considered locally to be of higher quality, it may change their attitude to their local neighbourhood and may improve social cohesion (4).

*In addition, in order to ensure that interventions meet the needs of users.*

### **Include appropriate signage and route information**

*In order to support and promote use of greenspaces provide clear signage and route information for users.*

### **Link with programmes which promote active use of area**

In order to address lack of awareness, interest and difficulties with access, it is important to raise awareness to enable such use (4). Organising activities in such places can stimulate first visits and thus continued use (4). *The interventions logic model provides more information on this topic.*

### **Increase the quantity, quality and accessibility of natural environments**

The report for DEFRA (3) stated that the evidence supported increasing the quantity and quality of greenspaces to benefit health and prevent ill-health. It indicated that natural environments which are well maintained (safe, litter free) are associated with good health and wellbeing. Researchers have suggested that safety, aesthetics, amenity and maintenance are important determinants of park use (3,4). As perceptions of the physical and the social environments are inextricably linked in many users' minds, actions to encourage use should consider both of these aspects in terms of quality.

### **Use a planting layout which is conducive to a positive airflow**

The cooling effect of vegetation through the provision of shade and evaporation can help to generate air flows which disperse air pollutants (4). A careful selection of species and planting layouts which optimise airflow and shade, combined with good maintenance, can optimise any beneficial effects on air quality (4).

### **Select planting species whose pollen is not allergenic**

*In order to limit exacerbation of allergic responses which may also lead to asthma attacks.*

## **2.6 GREENSPACE LOGIC MODEL: INPUTS**

### **Supportive, enabling policies and strategies and financial/political will, leadership, capacity and ownership**

*In order to enable the long-term viability of the project*

### **Availability and accessibility**

The report for DEFRA (3) described what it calls a "significant volume of evidence" of an association between the quantity and quality of natural environments, their proximity to the living environment and health outcomes. While the authors argue that an understanding of the potential dose response is "limited but growing", the evidence supports improving availability and accessibility (3). These were also listed as determinants of use in the INHERIT report (4).

### **Aesthetics**

The authors of the report for DEFRA (3) listed the following attributes of greenspace which may attract use: historical and cultural associations; perceived spaciousness; the richness of natural species in the area; qualities of peacefulness and wildness. In order to reduce the risk of over-exposure to UV radiation, the WHO report (2) proposed the inclusion of a tree canopy in the design of such places. Positive associations have been found between physical activity levels and wooded areas, water features, and pleasant views (2).

### **Amenities and equipment**

The amenities offered by spaces can enable or deter outdoor activities (2) and those which support use may vary between population groups and type of use (5). The report for DEFRA underlines the importance of including amenities which support use by older age groups (3), and the WHO reported that this age group are attracted by seating at staggered intervals, trees, greenery and toilets (2). The review for NICE (5), however, quoted a study which found that the provision of seating increased sedentary behaviour in mobile adults.

A Canadian study found that a paved trail, water area and playground were more important in supporting physical activity levels of users than drinking fountains, picnic areas and restrooms.

Positive associations have been found between physical activity levels and walking or cycling routes, lights, pleasant views, a bike rack and parking for cars (2). The NICE review (5) underlined the importance of regular maintenance and adequate lighting to allay fears and facilitate use of new paths and parks (5).

*In order to minimise injuries resulting from falls in children's play areas, appropriate surfaces should be provided in such areas.*

### **Management and maintenance**

The management of greenspaces in terms of “environmental incivilities”, e.g. picking up litter and cleaning off graffiti, are important in ensuring that such greenspaces do not represent a threat to the local community or other users and encourage wider use (4, 5). Tree cover which is overgrown or unmanaged could result in an increased fear of crime and anxiety (4).

To limit the risk of infection with *Toxocara canis* from the ingestion of dog faeces, these should be removed, and dog access to children's play areas should be limited (2).



### 3. Evidence: Elements of the therapeutic and other interventions in greenspaces logic model outlined in Figure 3

*Note: In order to facilitate connection with the logic models outlined above, headings and subheadings below are provided in the same colour as the box outlines of the logic models.*

#### 3.1 INTERVENTIONS LOGIC MODEL: DISTAL OUTCOMES

Distal outcomes describe possible impacts on global issues such as biodiversity, climate change and sustainable development. It is recognised that given the scale of the NHS estate, the impacts may be minimal, however thinking about such issues in the planning and maintenance of green spaces may provide a contribution to larger scale plans, national commitments, policies and strategies.

##### **Climate change mitigation and adaptation**

The level of mitigation would depend on the nature and success of the intervention. If an intervention encourages people out of their private transport and using more active forms of travel (such as walking or cycling) then this could affect transport emissions (4).

*Appropriate design, planting and landscaping may affect the impact of the grounds to hold back flood water, and the planting of trees contribute to carbon storage.*

##### **Enhanced biodiversity**

*The level of biodiversity attained will depend on the planting and maintenance planning and implementation for any project. The mix and type of plants will influence biodiversity directly and also through their contribution to healthy wider ecosystems of organisms.*

#### 3.2 INTERVENTIONS LOGIC MODEL: LONG-TERM OUTCOMES

In a 2016 review of nature-based interventions for mental health care for Natural England (6), Bragg and Atkins defined “green care” as “*nature-based therapy or treatment interventions – specifically designed, structured and facilitated for individuals with a defined need*”. They argued that although a variety of different approaches have been identified under this heading, they tended to share a number of elements: the use of a coherent and deliberate strategy using contact with greenspace to generate benefits to aspects of health, the social environment or education; the provision of specific, regular, facilitated interventions for a particular participant group or groups of service users rather than simply a natural experience for the general public; and the services are commissioned. It could be argued that many of the interventions described as currently taking place within the grounds of NHS Lothian estate would fall into this definition.

That review described the evidence around social and therapeutic horticulture and gardening as “lacking synthesis” and highlighted the need for more research with a focus on psychosocial interaction. Elsewhere they described the evidence on conservation activities – saying that much of the quantitative evidence was inconclusive, with some psychological and quality of life outcomes identified (6).

##### **Better mental health**

The 2016 review of nature-based interventions for mental health care (6) identified a number of mental health benefits from social and therapeutic horticulture and environmental conservation. These included: a reduction in depression, anxiety and stress related symptoms; an improvement in dementia-related symptoms; increased attentional capacity and cognition. It also quoted a 2013 review of gardening and mental health which found

what it described as a “substantial body of evidence” demonstrating benefits to mental health from gardening interventions. The nature-based interventions review also quoted 3 studies (all from the same research team) which found a reduction in depression severity over a 12 week horticulture therapy intervention and an increase in social cohesion and activity. It reported that gardening interventions can alleviate the symptoms of dementia and Alzheimer’s disease and improve alertness, cognitive abilities and social skills (6).

The report for DEFRA (3) quoted a formal systematic review which had found that the use of dementia gardens was associated with less agitation.

In describing a systematic review of the health and wellbeing benefits associated with conservation activities, the report for DEFRA (3) described much of the quantitative evidence as inconclusive with some positive psychological and quality of life outcomes. Activities were perceived to be beneficial to health and wellbeing through the provision of exposure to natural environments and enjoyment as well as providing a sense of achievement and social contact (3) – see *the mental health section of the evidence underpinning Figure 1 above*.

### **Reduced inequalities**

*See the inequalities section of the evidence synthesis for Figure 1.*

### **Better physical health**

The WHO report (2) described a study of older people which found that those who partook of outdoor activities such as walking and cycling had higher levels of vitamin D.

The review of nature-based interventions for mental health care (6) quoted a previous systematic review which found that a majority of participants in conservation activities perceived that their physical and mental health had improved after taking part in environmental enhancement activities.

*For further information on contact with green and natural environments and long term physical health outcomes, see that section in the evidence section of the greenspace logic model.*

## **3.3 INTERVENTIONS LOGIC MODEL: MEDIUM TERM OUTCOMES**

### **Improved wellbeing**

A 2013 national evaluation of green gyms found significant improvements in wellbeing, self-esteem and overall mood in addition to social benefits for those who took part (6). Reported positive effects on psychological health and wellbeing included lower levels of stress, greater feelings of self-worth, feeling calmer and enhanced resilience (6). The review found that the majority of studies focussed on the general population with only a minority specifically addressing effects on those with mental ill-health and much of the evidence was inconclusive.

The review of nature-based interventions for mental health care reported a review of high quality qualitative studies which found wellbeing benefits from horticulture interventions: improved mood, a sense of peace or calm, a sense of connection and belonging (both to nature and other people); fascination; feelings of safety and security in a neutral environment (6). However, that report identified a consensus that social therapeutic horticulture and gardening studies still lacked synthesis.

Improvements to mental wellbeing have been reported for walking groups (3).

### **Improved social cohesion**

The report for DEFRA (2) quoted a systematic review which found that conservation activities were perceived to be beneficial to health and wellbeing through (amongst others) a sense of achievement and social contact.

The INHERIT report (4) argued that social contact is important for health and wellbeing, particularly where social isolation is associated with increased mortality (2). This can be a particular issue in people in older age groups who may be experiencing a number of transitions – retirement, personal or spousal ill-health, caring responsibilities and bereavement. Participants of this age group in activities such as group-based conservation and gardening activities have reported an appreciation of the opportunities for structure and routine; meaningful social interaction and the development of stronger communities; a sense of achievement, pride and ownership; and the forging of new social identities (4).

### **Participants have new skills and sense of purpose**

Reported positive effects on psychological health and wellbeing included lower levels of stress, greater feelings of self-worth, feeling calmer and enhanced resilience (6).

The INHERIT report (4) argued that social contact is important for health and wellbeing, particularly where social isolation is associated with increased mortality (2). This can be a particular issue in people in older age groups who may be experiencing a number of transitions – retirement, personal and spousal ill-health, caring responsibilities and bereavement. Participants of this age group in activities such as group-based conservation and gardening activities have reported an appreciation of the opportunities for structure and routine; meaningful social interaction and the development of stronger communities; a sense of achievement, pride and ownership; and the forging of new social identities (4).

### **Improved blood pressure, lower cholesterol levels, weight loss**

A meta-analysis of outdoor walking groups quoted in the report for DEFRA (3) found lower blood pressure, resting heart rate, body fat, Body Mass Index, cholesterol and improved lung function.

## **3.4 INTERVENTIONS LOGIC MODEL: SHORT-TERM OUTCOMES**

### **Participants meet new people**

The INHERIT report (4) argued that social contact is important for health and wellbeing, particularly where social isolation is associated with increased mortality (2). This can be a particular issue in people in older age groups who may be experiencing a number of transitions – retirement, personal and spousal ill-health, caring responsibilities and bereavement. Participants of this age group in activities such as group-based conservation and gardening activities have reported an appreciation of the opportunities for structure and routine, meaningful social interaction and the forging of new social identities. Improved social contact, inclusion and a sense of belonging have also been reported as an outcome of green care activities (6).

### **Participants enjoy time in natural environments**

There is evidence from a systematic review of health and wellbeing benefits associated with conservation activities quoted in the report for DEFRA (3) that while much of the quantitative evidence was inconclusive, some positive psychological and quality of life outcomes have been identified. The activities were perceived to be beneficial through providing exposure to natural environments and enjoyment as well as a sense of achievement and social contact.

The INHERIT report (4) quoted a review which had found evidence that people with dementia who were living in care homes, their families and care home staff reported appreciating the presence of a garden which allowed for relaxation and which could also stimulate memories and activities. It was reported that such gardens could also provide an opportunity to maintain life skills and habits and could give a normalising context for residents' interactions with visitors and staff.

### **Participants enjoy arts based activities**

*Where these form a part of the intervention/project.*

### **Participants are more physically active**

*See "Use and function: active mobility" and "use and function: physical activity and sports" in the evidence section on figure 1, above.*

The NICE review (5), using the evidence quality criteria generally accepted for clinical medicine, described evidence of a relationship between access to greenspace and physical activity levels as "poor" (5). The DEFRA report (3) described the evidence as showing "generally positive associations" in selected groups, but indicated that no causality had been proved, citing methodological problems in identifying the direction of causality – do people choose to live in greener areas because they like walking and cycling or does the experience of living in such areas encourage walking and cycling (or is it a mixture of both)? There is some evidence that woodlands, gardens, parks, grassland and farmland may be supportive of vigorous activity (3).

### **People with dementia: alleviation of symptoms**

There is evidence from a formal systematic review that the use of dementia gardens was associated with a decrease in agitation (3). Residents in care homes who have dementia, their families and care home staff have reported that such gardens allow for relaxation and could stimulate memories (4). Social and therapeutic gardening has been reported to alleviate the symptoms of dementia and improve alertness, cognitive ability and social skills (6).

There is evidence of an association between regular participation in gardening and a lower risk of the development of dementia (6), this may be at least partly mediated by the physical exercise which gardening requires. One study found that a group of people with early onset dementia a 12 month programme of horticulture therapy had a positive impact on the wellbeing, cognition and mood of participants (6).

For patients with dementia, there is also review level evidence regarding social and therapeutic gardening and: reductions in pain, stress, agitation, disruptive behaviour and falls; the dispensing of fewer "as need" medications and antipsychotics; improvements in patient attention and wellbeing; and improvements in function levels, sleep and sleep patterns (6). However, the report (6) also indicated a need for more controlled clinical trials and quantitative evidence in this area (6).

### **Food production and consumption**

There is some evidence (2) that using greenspace for growing food may contribute to levels of physical activity and social wellbeing and encourage a healthy diet (by consumption of fruit and vegetables grown).

### **Improved quality and management of greenspaces**

*The contribution of an intervention to the quality and management of greenspaces would depend on decisions on the structure, planting, use and maintenance of such areas. This is covered more fully in the logic model provided in Figure 1.*

### **3.5 INTERVENTIONS LOGIC MODEL: ACTIVITIES/OUTPUTS**

#### **Appropriate participants are identified, invited, recruited and supported to attend sessions**

There is evidence that in terms of impacts on mental health, a range of vulnerable groups may benefit from nature-based interventions (6). These include: people with mental health problems; people experiencing mild to moderate depression; people with dementia; adults and children with learning disabilities; adults and children with autistic spectrum disorders; people with a history of drug or alcohol addictions; disaffected young people; and adults on probation (6).

#### **Coordination, management and support of volunteers**

*Where volunteers are part of the project, in order to ensure continuing viability of the project. This would include appropriate training and recognition.*

#### **Sessions are organised and run in safe and accessible green and natural spaces**

*Integral to definition.*

#### **Appropriate transport provided/available to the site**

*In order to ensure participants, volunteers and staff (as appropriate) are able to attend sessions, from discussions in the workshops this may include clinical staff to provide the right level of support for participants.*

#### **Appropriate activities are supported and tools and equipment supplied if and as appropriate**

*These will vary according to the aims and structure of the interventions.*

#### **Sessions are sociable**

*In order to ensure that the social benefits of participation are realised.*

#### **Participants learn and share new skills**

*In order to ensure that the skills and sense of purpose benefits of participation are realised.*

#### **People are active during sessions**

*In order to ensure that physical activity benefits of participation are realised.*

#### **Greenspaces are changed – paths, trees, signs, planting etc**

*Any changes are dependent on the aims of the project, see the evidence section for Figure 1 for further information on hard landscaping, planting etc to maximise positive benefits to health and minimise any negative impacts.*

### **3.6 INTERVENTIONS LOGIC MODEL: INPUTS**

#### **Engagement with clinical and proposed users on usefulness and shape of project**

*As a practical exercise to ensure long-term buy-in for and support of the project, and to ensure that the intervention meets the needs of the proposed client group.*

The INHERIT study (4) also suggested that this may lead to an increased motivation to consider more sustainable and environmentally friendly behaviours.

#### **Engagement with wards/hospital staff, GPs/other sources of referrals, and support**

*To ensure a ready flow of participants and that where these people are inpatients, sessions are run at a time which is compatible with their inpatient care.*

#### **Sessions are planned to meet health, social and/or environmental aims**

In a 2016 review of nature-based interventions for mental health care for Natural England (6), Bragg and Atkins defined “green care” as “nature based therapy or treatment interventions – specifically designed, structured and facilitated for individuals with a defined need”.

#### **Skilled trainers/leaders/volunteers**

*In order to ensure that the intervention meets its stated aims and participants enjoy the experience and want to continue with it.*

#### **Greenspace in which to work**

*Integral to the topic definition*

#### **Financial/political will, leadership, capacity and ownership, supporting and enabling policies and strategies**

*In order to ensure support and continued support for the intervention – workshop discussion stressed the importance of these for the success of any intervention.*

#### **Long term, secure funding**

*In workshop discussion, the problems of attracting ongoing funding and the impact of this on projects was agreed as an issue.*

#### **Positive role models**

*In order to ensure that the project is able to recruit participants and meet its stated aims*

#### **Project and activities are promoted in the community and participants recruited**

*In order to ensure an appropriate flow of participants.*

## 4. Conclusions

The evidence synthesis from the reviews which were consulted found strongest evidence about the links between experience of, or contact with greenspaces and mental health and wellbeing, stress reduction, the alleviation of dementia symptoms and a relationship with health inequalities, with generally positive links being found for outcomes such as cardiovascular disease, mortality, physical activity, social cohesion, pregnancy outcomes and children's cognitive development.

It would appear that different groups within the population may respond differently to greenspace in terms of their age, gender, ethnic or cultural background, health status and socioeconomic status. Some of this may be mediated by individual perception, which may mean that interventions need to be tailored to suit the needs and preferences of the target populations. The evidence base is growing but is not yet at the stage where definitive statements can be made about impacts of inclusion or exclusion of specific elements of projects.

Environmental outcomes will be dependent on decisions made about the design, implementation and ongoing management and maintenance of the grounds.

The logic models provide a framework on which to report the evidence, and to report some of the issues required for successful interventions which were discussed at the workshop. They provide theoretical paths through from greenspace and interventions in greenspace and health and wellbeing outcomes, and as such may be of use in the design of projects, consideration of project funding, and subsequent evaluation of such projects.

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