Literature screening report

Scoping review on the effectiveness of movement-friendly environments on health: contact with nature and greenspaces

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Abstract

Access to greenspaces and contact with nature are key features of environments that can promote physical activity and contribute to positive physical and mental health. The purpose of this scoping review was to examine the current research on the effectiveness of movement-friendly environments, specifically the impact of greenspaces and contact with nature on behaviour change and health outcomes. The review takes a comprehensive approach to identify intervention strategies that offer co-benefits for both human health and the environment, including addressing issues related to climate change and biodiversity. A total of 122 combined scientific articles (n=117) and grey literature reports (n=5) were included in the review. The majority focused on greenspaces (n=92), with a smaller number focusing on both green and blue space (n=16), blue spaces (n=6), and the intersection of these with active mobility infrastructures (n=8). A large portion of the identified scientific articles were literature reviews of different types (n=67), the remaining articles were observational and experimental studies (n=50). Health outcomes are presented in this report according to intervention type. Key interventions with important co-benefits include access and quality of greenspace, access to blue spaces and nature-based therapies or green prescriptions.

Access and exposure to greenspaces have a positive relationship with overall health and well-being, and offer various social benefits. Positive relationships with mental health outcomes include those such as reduced risk of stress, depression (for example, amongst a Finish cohort, OR: 0.56; 95% CI 0.33 to 0.96; [40]), and anxiety. Benefits for physical health relate to the reduced risks of numerous non-communicable diseases such as atopic and respiratory diseases, type two diabetes, stroke, coronary

heart disease, ischemic heart disease, and cardiovascular disease [risk ratio (95%CI) = 0.96 (0.94,0.97), p-het = 0.26][54]. Furthermore, there is strong evidence to support the reduced risk of all-cause mortality [risk ratio (95%CI) = 0.92 (0.87, 0.97), p-het<0.001] [54]. The density and quality of greenspace is associated with multiple physical and mental health outcomes, such as reduced psychological distress, increased physical activity (for example, people living in areas with high greenness across eight European cities [OR: 3.32; 2.46 to 4.50; p<0.001]) [101], and reduced risk of obesity (again, for people living in areas with high greenness across eight European cities [OR: 0.63; 0.49 to 0.82; p<0.001]) [101], particularly for individuals from low socioeconomic backgrounds and minority groups. The health benefits of engaging with nature vary based on population groups, with lower-income or less-educated groups benefiting the most. Access or exposure to blue space is associated with overall health benefits and positive mental health outcomes, such as reduced stress and mood disturbance. Outdoor activities in natural environments and exercise interventions in greenspaces have a positive impact on well-being, mood, and physical activity. However, few studies have established a causal relationship between access to greenspaces and physical activity, and the relationship between greenspaces and obesity is mixed. Finally, nature-based therapies, green care, or green prescription are effective in improving mental health outcomes, reducing anxiety (SMD: 0.94; 95% CI: 0.94 to 0.01) [83], reduce depression (SMD: 0.64; 95% CI: 1.05 to 0.23) [83], and improving overall health.

Based on these findings, it is important to increase access to greenspaces for populations, particularly those from low socioeconomic backgrounds and minority groups, paying attention to the quality of greenspaces, particularly in deprived neighbourhoods. Nature based therapy and green prescription, health promotion initiatives, exercise interventions, and innovative playground design can also encourage outdoor activities and behaviour change. It is important to consider the context and specific needs of different groups of users when planning greenspace interventions. Furthermore, it is important to note an important limitation exists regarding the comparability of the diversity of greenspaces, how they are characterized and their quality when common proxy measures for greenness are used. Additionally, responsible governance, management, and use of greenspaces are crucial to minimize public health risks and human disturbance of species and nature.

Résumé Français

L'accès aux espaces verts et le contact avec la nature sont des caractéristiques essentielles d'un environnement pour promouvoir l'activité physique de la population et contribuer à sa bonne santé physique et mentale. L'objectif de cette revue de littérature est de faire l'état des lieux des recherches sur les environnements favorables à l'activité physique, en particulier sur les espaces verts et le contact avec la nature, et leurs effets sur les changements de comportement ainsi que l'impact sur la santé. L'étude a cherché à identifier les stratégies d'intervention qui offrent des avantages à la fois pour la santé humaine et pour l'environnement (co-bénéfices), notamment en abordant les questions liées au changement climatique et à la biodiversité. Au total, 122 articles scientifiques (n=117) et rapports de littérature grise (n=5) ont été inclus dans l'étude. La majorité d'entre eux porte sur les espaces verts (n=92), et dans une moindre mesure sur les espaces verts et bleus (n=16), les espaces bleus uniquement (n=6) et l'intersection de ces derniers avec les infrastructures de mobilité active (n=8). Une grande partie des articles scientifiques identifiés sont des revues de littérature (n=67), les autres étant des études observationnelles et expérimentales (n=50). Dans ce rapport, les effets sur la santé sont présentés en fonction du type d'intervention. Les interventions présentant des co-bénéfices importants

sont principalement l'accès et la qualité des espaces verts, l'accès aux espaces bleus et la thérapie par la nature ou les prescriptions vertes.

L'accès et l'exposition aux espaces verts sont positivement associés avec la santé et le bien-être en général. Ils offrent également divers avantages sociaux. Les résultats en matière de santé mentale comprennent la réduction du risque de stress, de dépression (par exemple, dans une cohorte finlandaise, OR : 0,56 ; 95% CI 0,33 à 0,96 ; [40]) et d'anxiété. Les avantages pour la santé physique sont liés à la réduction des risques de nombreuses maladies non transmissibles telles que les atopies, les maladies respiratoires, le diabète de type 2, les accidents vasculaires cérébraux et les maladies cardiovasculaires [rapport de risque (95%CI) = 0.96 (0.94,0.97), p-het = 0.26][54]. En outre, une diminution du risque de mortalité toutes causes confondues est clairement établie [rapport de risque (95%CI) = 0.92 (0.87, 0.97), p-het<0.001] [54]. La densité et la qualité des espaces verts sont associées à de multiples effets sur la santé physique et mentale, tels que la réduction de la détresse psychologique, l'augmentation de l'activité physique (par exemple, les personnes vivant dans des zones à haut couvert végétal dans huit villes européennes [OR : 3,32 ; 2,46 à 4,50 ; p<0,001]) [101], et la réduction du risque d'obésité (là encore, pour les personnes vivant dans des zones à haut couvert végétal dans huit villes européennes [OR : 0,63 ; 0,49 à 0,82 ; p<0,001]) [101], en particulier pour les personnes issues de milieux socio-économiques défavorisés et de groupes minoritaires. Les avantages pour la santé d'un contact avec la nature varient en fonction des groupes de population, les groupes à faible revenu ou ayant un niveau d'éducation plus bas étant ceux qui en bénéficient le plus. L'accès ou l'exposition aux espaces bleus est associé à des bienfaits globaux pour la santé et à des effets positifs sur la santé mentale, tels que la réduction du stress et des troubles de l'humeur. Les activités de plein air dans des environnements naturels et les exercices physiques dans les espaces verts sont associés à des effets positifs sur le bien-être, l'humeur et l'activité physique. Toutefois, peu d'études ont exploré les mécanismes de causalité entre l'accès aux espaces verts et l'activité physique. De la même manière, les liens entre espaces verts et obésité e sont moins claires. Enfin, les interventions de type thérapie par la nature, « green care » ou les prescriptions vertes sont efficaces pour améliorer la santé mentale, réduire l'anxiété (SMD: 0.94; 95% CI : 0.94 à 0.01) [83], réduire la dépression (SMD: 0.64; 95% CI : 1.05 à 0.23) [83], et améliorer l'état de santé général.

Sur la base de ces résultats, il est important d'étendre l'accès de la population aux espaces verts, en particulier des populations issues de milieux socio-économiques défavorisés et de groupes minoritaires. Cet accès doit être garanti tout en prêtant attention à la qualité des espaces verts, en particulier dans les quartiers défavorisés. Peuvent également encourager les activités en plein air et les changements de comportement : la thérapie par la nature et les prescriptions vertes, les initiatives de promotion de la santé, les interventions en matière d'exercice physique et la conception d'aires de jeux innovantes. Il est aussi important de tenir compte du contexte et des besoins spécifiques des différents groupes d'utilisateurs lors de l'aménagement d'espaces verts. En outre, une gouvernance, une gestion et une utilisation responsables des espaces verts sont essentielles pour minimiser les risques pour la santé publique et la perturbation anthropique des espèces et de la nature.

<u>Zusammenfassung Deutsch</u>

Der Zugang zu Grünflächen und der Kontakt mit der Natur sind wesentliche Merkmale von Umgebungen, die körperliche Aktivität fördern und zu einer positiven körperlichen und mentalen Gesundheit beitragen können. Das Ziel dieser Literaturrecherche ist, den Forschungsstand

bewegungsfreundlicher Umgebungen zu untersuchen, insbesondere die Auswirkungen von Grünflächen und Kontakt mit der Natur auf Verhaltensänderungen und Gesundheitsergebnisse. Die Untersuchung verfolgt einen umfassenden Ansatz, um Interventionsstrategien zu ermitteln, die sowohl für die menschliche Gesundheit als auch für die Umwelt von Vorteil sind, einschliesslich der Behandlung von Fragen im Zusammenhang mit dem Klimawandel und der biologischen Vielfalt. Insgesamt sind 122 wissenschaftliche Artikel (n=117) und Berichte über graue Literatur (n=5) in die Untersuchung einbezogen. Die Mehrheit der Artikel befasst sich mit Grünflächen (n=92), eine geringere Anzahl mit Grün- und Bauräumen (n=16), mit Bauräumen (n=6) und mit deren Überschneidung mit aktiven Mobilitätsinfrastrukturen (n=8). Bei einem grossen Teil der identifizierten wissenschaftlichen Artikel handelt es sich um Literaturübersichten unterschiedlicher Art (n=67), bei den übrigen Artikeln geht es um Beobachtungs- und experimentelle Studien (n=50). Die Gesundheitsergebnisse sind in diesem Bericht nach Interventionstyp dargestellt. Zu den Interventionen mit wichtigen Zusatznutzen gehören insbesondere der Zugang zu Grünflächen und deren Qualität, der Zugang zu blauen Flächen und naturbasierte Therapien oder Park-Verschreibungen.

Der Zugang zu und der Kontakt mit Grünflächen stehen in einem positiven Zusammenhang mit der allgemeinen Gesundheit und dem Wohlbefinden und bieten verschiedene soziale Vorteile. Positive Zusammenhänge mit der psychischen Gesundheit bestehen beispielsweise in der Verringerung des Risikos von Stress, Depressionen (z. B. in einer finnischen Kohorte, OR: 0,56; 95% CI 0,33 bis 0,96; [40]) und Angstzuständen. Die Vorteile für die körperliche Gesundheit beziehen sich auf die Verringerung des Risikos zahlreicher nicht übertragbarer Krankheiten wie atopische und Atemwegserkrankungen, Typ-2-Diabetes, Schlaganfälle, und Herz-Kreislauf-Erkrankungen [Risikoverhältnis (95%CI) = 0,96 (0,94,0,97), p-het = 0,26][54]. Ausserdem gibt es überzeugende Belege für ein geringeres Risiko der Gesamtmortalität [Risikoverhältnis (95%CI) = 0,92 (0,87, 0,97), p-het<0,001] [54]. Die Dichte und Qualität von Grünflächen ist mit einer Vielzahl von physischen und psychischen Gesundheitsergebnissen in Verbindung gebracht, wie z. B. geringerer psychischer Störungen, erhöhter körperlicher Aktivität (z. B. Menschen, die in Gebieten mit hohem Grünanteil in acht europäischen Städten leben [OR: 3,32; 2,46 bis 4,50; p<0,001]) [101], und einem geringeren Risiko für Fettleibigkeit, (hier wieder für Menschen, die in Gebieten mit hohem Grünanteil in acht europäischen Städten leben [OR: 0,63; 0,49 bis 0,82; p<0,001]) [101], insbesondere bei Personen mit niedrigem sozioökonomischem Hintergrund und Minderheitengruppen. Die gesundheitlichen Vorteile der Kontakt mit der Natur variieren je nach Bevölkerungsgruppe, wobei einkommensschwache oder weniger gebildete Gruppen am meisten davon profitieren. Der Zugang zu bzw. die Exposition gegenüber Grünflächen ist mit allgemeinen gesundheitlichen Vorteilen und positiven Auswirkungen auf die psychische Gesundheit in Verbindung gebracht, wie z. B. weniger Stress und Stimmungsschwankungen. Outdoor-Aktivitäten in natürlicher Umgebung und Bewegungsinterventionen in Grünanlagen wirken sich positiv auf das Wohlbefinden, die Stimmung und die körperliche Aktivität aus. Allerdings haben nur wenige Studien einen kausalen Zusammenhang zwischen dem Zugang zu Grünflächen und körperlicher Aktivität hergestellt, und die Beziehung zwischen Grünflächen und Fettleibigkeit ist uneinheitlich. Schliesslich sind naturbasierte Therapien, «Grüne Pflege» oder Park-Verschreibungen wirksam bei der Verbesserung der mentalen Gesundheit, der Verringerung von Ängsten (SMD: 0,94; 95% CI: 0,94 bis 0,01) [83], Depressionen zu verringern (SMD: 0,64; 95% CI: 1,05 bis 0,23) [83] und der Verbesserung der allgemeinen Gesundheit.

Auf der Grundlage dieser Erkenntnisse ist es wichtig, den Zugang der Bevölkerung zu Grünflächen zu verbessern, insbesondere für Menschen mit niedrigem sozioökonomischem Hintergrund und für

Minderheitengruppen. E sollte dabei auf die Qualität der Grünflächen geachtet werden, vor allem in benachteiligten Stadtvierteln. Naturbasierte Therapien und Park-Verschreibungen, Initiativen zur Gesundheitsförderung, Bewegungsinterventionen und innovative Spielplatzgestaltung können ebenfalls Aktivitäten im Freien und Verhaltensänderungen fördern. Es ist wichtig, bei der Gestaltung von Grünflächen den Kontext und die spezifischen Bedürfnisse der verschiedenen Nutzergruppen zu berücksichtigen. Darüber hinaus sind eine verantwortungsvolle Verwaltung, Bewirtschaftung und Nutzung von Grünflächen von entscheidender Bedeutung, um Risiken für die öffentliche Gesundheit und die anthropogene Störung von Arten und Natur zu minimieren.

Content

Preamble

A large number of scientific publications become available on a daily basis, reflecting the rapid development of knowledge and progress of science on the link between greenspaces and contact with nature with human health and environmental co-benefits. Leading authorities should base decisions or policies on this knowledge; hence they need to master the actual state of this knowledge. Due to the large number of publications shared daily, decision makers heavily depend on accurate summaries of these publications, in the different public health domains. Therefore, the authors of this report were mandated by the Swiss School of Public Health plus (SSPH+), on request of the Federal Office of Public Health (FOPH), to inform the FOPH on recent findings from the literature.

Background

Contact with nature through greenspaces are important aspects of movement-friendly environments which promote behaviour change and positive physical and mental health outcomes [1-4]. Access to greenspace within 300m of residences is recommended by the World Health Organization (WHO) as a means to promote positive physical and mental health outcomes [5]. Identified health benefits of greenspaces includes positive associations between exposure to urban greenspaces and physical activity, as well as protective effects for reducing negative health outcomes such as risks associated with mortality, mental health outcomes and stress, and cardiovascular diseases [1-3]. Furthermore, the WHO and scientists worldwide have highlighted the value of greenspaces for increasing biodiversity, and reducing air pollution and urban heat islands [6-8]. Such win-win interventions, here referred to as co-benefits, are both positive for human health and the environment [9]. Actors involved in urban planning and infrastructure management have important roles in ensuring the future development of greenspaces that are simultaneously supportive of human health and well-being, and environmentally sustainable [4]. However, a better understanding of the effectiveness of such strategies, the identification of specific interventions, and the exploration of potential barriers and facilitators is necessary to inform the design of policies and programs that promote good physical and mental health while also protecting the environment.

The aim of this scoping review is to gain a better understanding of existing research relating to the effectiveness of movement-friendly environments, in particular contact with nature through greenspaces and parks, in terms of their impact on behaviour change and health outcomes. A prism of co-benefits has been adopted in the review to aid with the identification of win-win intervention strategies for human health and the environment, particularly climate change and biodiversity. This report outlines the methodology, and key findings in terms of health outcomes, behavioural change and co-benefits.

Definitions of key concepts

Movement/exercise-friendly environment - Although no consensual definition of “a movement-friendly environment” exists, it can be described as built or designed (urban or rural) infrastructure that support and facilitate physical movement, exercise, and activity. This can include features such as greenspaces; accessible paths for cycling, walking or other forms of active mobility; and areas specifically designed for physical activity (for example, parks, playgrounds, exercise stations, and certain sport infrastructures such as sports fields).

Greenspaces – While there are a wide range of definitions of greenspace in the literature, in this report, greenspaces are understood as areas of land openly accessible to the public that are designed to provide a natural environment for community members and access to spaces for recreational uses [8]. These can include national parks and reserves, forests, parks, gardens, and other types of open spaces such as those designed for recreation and leisure activities, for example public playgrounds, sports fields, picnic areas, designated hiking and bike trails, among others. In the present review, blue space is considered under the "greenspaces" umbrella term. Blue spaces are visible surface waters in public space, this includes streams, lakes, rivers, waterfalls, etc [10].

Access or proximity to greenspace, often referred to as 'greenness' exposure or contact with nature, is commonly measured through proxy measures such as density or percentage of green space in a given area, or the normalized difference vegetation index (NDVI) which quantifies vegetation through remote-sensing that measures the difference between near-infrared and red light which are strongly reflected and absorbed by vegetation [8].

Urban green spaces – Urban green spaces are considered as a sub-set of greenspaces in general which refers to vegetated land that surrounds or separates areas of concentrated residential or commercial activity this can include parks, urban forests, ponds, lakes, streams, street trees, natural strips, vegetated roofs, walls, gardens or other urban green infrastructure [5, 8].

Built environment – The built environment refers to the human-made features and physical infrastructure, including buildings, roads, bridges, parks, among other infrastructure in which people live, work and carry out recreational activities [11].

Co-benefits – According to the IPCC, co-benefits are "the positive effects that a policy or measure aimed at one objective might have on other objectives, thereby increasing the total benefits to the society or environment" [12, p. 873]. Sometimes called win-win strategies, co-benefits within the context of health are interventions that are simultaneously beneficial for maintaining, restoring or improving both human health and the environment [9]. Within the context of this literature screening, a specific focus is placed on health co-benefits for biodiversity and climate change.

Biodiversity – The "variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" [7, p. 14]. Biodiversity is recognised by the WHO as a critical natural feature underpinning ecosystem functioning which results in the provision of ecosystem goods and services which are vital for human health.

Questions addressed

- 1) What are the impacts of **contact with nature through greenspaces** on behavioural change?
- 2) What are the impacts of **contact with nature through greenspaces** on physical and mental health?
- 3) What are the co-benefits of **contact with nature through greenspaces**?

Methodology

The scoping review focused on greenspaces and three specific outcomes are of interest, including: a) impacts on behavioural change, b) impact on physical and mental health, and c) environmental co-benefits. This review has been conducted in accordance with the PRISMA guidelines for reporting scoping literature reviews [13]. The full search strategies were developed in collaboration with librarians specialized in health literature searches of Unisanté (University of Lausanne). Combinations of the key search terms such as 'green space', 'greenspace', 'greening', 'greenness', 'parks', 'community garden', 'green infrastructure', 'blue space', 'health behaviour change', 'healthy behaviour', 'physical activity', 'physical health', 'mental health', among others were used to identify relevant literature (full list available in Appendix 1). Databases which were used for the search include PubMed and EMBASE. Relevant articles were then selected according to the established criteria (Appendix 2), including geographic focus on Europe, and in particular Switzerland.

The initial greenspace search was complimented with a specific search dedicated to blue spaces to ensure an adequate number of studies related to blue spaces were also identified in the search. Furthermore, for outcome c) *environmental co-benefits*, the research team also drew on a pre-existing literature review previously conducted by members of the team [4, 14]. In addition to the scientific literature, grey literature from reputable international organisations in relevant domains were also used to complement the scientific literature and identify pertinent case studies that can serve as good practice examples illustrating pertinent interventions.

The scoping review identified a total of 122 combined scientific articles and grey literature reports. This included 107 scientific articles identified through the search that examined the relationships between green and blue spaces and the three outcomes of interest. An additional 10 scientific articles as well as five reports were included through citation and grey literature searches, respectively. Figure 1 provides a flow diagram of the articles and grey literature included in the review. Of this literature the majority focused on greenspaces (n=92), with a smaller number focusing on blue spaces (n=6). Several were identified that focus on both green and blue space (n=16), and the intersection of these with active

mobility infrastructures (n=8). A large portion of the identified scientific articles were literature reviews of different types (n=67; including meta-analysis n=1, systematic review and meta-analysis n=8, systematic review n=30, review of reviews n=3, scoping review n=3, rapid review n=2, and narrative review n=20). The remaining articles were observational and experimental studies (n=50, including: case control studies n=2, cohort studies n=15, cross sectional studies n=14, non-randomised experimental studies n=9, Randomized cross-over studies n=2, randomised controlled trials n=4, and health impact assessments or modelling studies n=4).

The strength of evidence was based on a qualitative assessment using the Oxford Centre for Evidence-Based Medicine Levels of Evidence as a guiding framework [15]. “Strong evidence” in this report primarily refers to systematic reviews and meta-analyses, particularly of randomised control trials, nested case-control studies and prospective cohort studies.

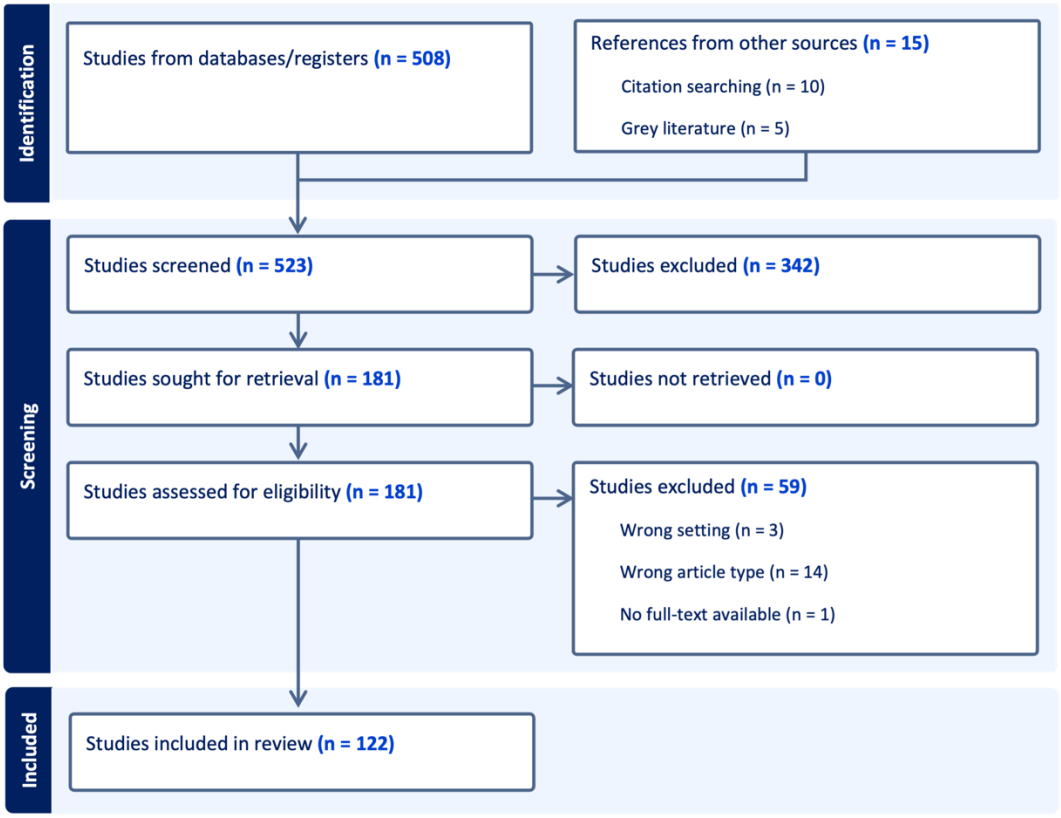

Figure 1. Main stages of the scoping review process indicating the number of scientific articles processed

Results and Findings

1) What are the impacts of **contact with nature through greenspaces** on behavioural change?

Summary:

Only a small portion of the identified academic and grey literature addressed behaviour change with regards to greenspaces and health (n=8). Behaviours explored included first and foremost users and uses (such as the number of park visitors, types of activities and when greenspaces are used). Physical activity and the use of park and mobility infrastructure for leisure time exercise or active mobility was also a focus in the literature relating to behaviour change. Physical activity appears in the literature as both a focus of behavioural change and health outcome. This includes walking, cycling, play, and what is referred to in the literature as 'moderate to vigorous physical activity'. Other behavioural changes explored include a small number of articles exploring pro-environmental behaviour and smoking behaviour.

Results:

A Swiss study that examined the accessibility of urban greenspace found that 75% of the Swiss population are within five minutes of urban green space if motorised transport is used [16]. Similarly, 36% of the Swiss population are within 15 minutes of urban green space (if motorised transport is used). Furthermore 72% of the population are within five minutes of the nearest forest, and 52% are within 15 minutes of a forest, again if motorised transport is used [16]. It is important to note that accessing greenspaces by motorised transport does not offer the associated health benefits which would come from accessing greenspaces through active transport. For example, having access on foot to public greenspace has been found to potentially prevent 205 (155–306) years of life lost per 100 000 inhabitants in Zurich (95% CI) [17]. Additionally, the use of motorised transportation to access greenspaces not only constitutes a contribution to climate change through the emission of greenhouse gases, but also a missed opportunity for co-benefits that promote health and mitigating climate change through active transportation [6] (also see "Scoping review on the effectiveness of movement-friendly environments on health: mobility infrastructures" and Section 3 of this report). For these reasons, the WHO recommends that everyone live within 300m (approximately 5 minutes' walk) of public greenspaces of at least 5,000 to 10,000 Square Meters [5]. The proportion of the Swiss population that has access to greenspaces within 5 minutes' walk was not assessed in any of the identified studies.

As mentioned, park uses and users were the most commonly studied among the behaviour related literature. An observational study in Belgium found that male adults engaged in vigorous-intensity physical activity were the most common park users, with cycling, sitting, and walking being the most popular activities, and parks were used least frequently in the morning, during the weekend, and by seniors[18]. Neighbourhood walkability was positively associated with higher numbers of park visitors (β0.766; SE: 0.059; p<0.001), number of visitors walking (β 0.284; SE : 0.091; p<0.001), sedentary visitors (β0.653; SE: 0.147; p<0.001), and mean activity levels of visitors (β2.096 ; SE: 0.814; p<0.001) [19]. A survey of adolescents in high school settings in Scotland found that hanging around in a street or park more than once a week is associated with a threefold increase in intention to try e-cigarettes (OR 3.78; 99%CI= 1.93 to 7.39) [20]. There are mixed associations between gender and leisure time physical activity in parks [21]. It has been suggested that women are more fearful in urban greenspaces, however they often express a preference for safe greenspaces for physical activity compared to exercising in the street [8]. The number of visitors to parks in Belgium were lower in low-income communities, however they tended to be more vigorously active [19].

Public parks can serve as effective settings for interventions targeting youth to improve physical, mental, and emotional health outcomes [22]. Among the studies included in this scoping review, less literature exists infrastructure or renovation-based interventions in parks. Providing instructional information in the form of videos accessible via scannable QR codes can support correct use of park-based exercise equipment [23]. In the Netherlands and in the United Kingdom it has been determined that tailoring the design of playgrounds to include innovative designs, as well as lendable sports material and sports guidance in a safe environment, increases playground use and physical activity levels of youth in deprived neighbourhoods [24, 25]. The presence of other children playing is an important determinant of children engaging in moderate to vigorous physical activity in playgrounds [26].

Box 1. Playgrounds and physical activity

The **Krajicek playgrounds**[1] in the **Netherlands** follow a concept of playground design which tailors public playgrounds to encourage physical activity through provision of loose equipment, daily supervision during peak times, and a designated sports coach to organise activities. This has resulted in higher playground use and physical activity levels among children in deprived neighbourhoods.

Figure a. Playground Kop van Noord, Rotterdam

Figure b. Covered playground in Poelenburg

[1]For further information, please refer to Boonzajer Flaes et al. [24]. Figures are copyright of Krajicek Foundation (www.krajicek.nl)

Cyclists prefer to use longer routes when cycling infrastructure is present (for example bicycle lanes and pathways) rather than the shortest possible routes [27]. Similarly, they favour routes that take them through green and flat areas, or those with fewer traffic lights and crossings. They are more likely avoid main roads and crossings and consider topography as a factor in their choice of route. It has been determined that cyclists in Graz, Austria, tend to select routes with more green and blue areas [27].

Contact with nature has not only shown to increase various health outcomes, as discussed in the following section, it has also been suggested to improve sustainability-related behaviours. Individuals reporting high nature connectedness tend to have frequent and long-term contact with nature, exhibit ecologically aware attitudes and behaviours, and are more supportive of conservation and express greater environmental concern [7]. However, such relations were less obvious in the health research literature. Finally, the regeneration and upkeep of blue spaces, including the regeneration of rivers, waterfront and canals, has been identified as a factor that supports changes toward healthier lifestyles and supports healthy urban environments [28].

2) What are the impacts of **contact with nature through greenspaces** on physical and mental health?

Summary:

Health outcomes are the overwhelming focus of the literature included in this scoping review (n=105) when compared to literature focused on behavioural change outcomes and co-benefits. Identified themes of health outcomes treated in the literature include general overall health, mental health, physical activity and obesity, mortality and non-communicable diseases (including cardiovascular diseases and cancer), respiratory and immune function (including asthma and allergies), and childhood development and birth outcomes. Other health outcomes that appear less frequently in the literature include social benefits (such as social connectedness) and quality of life.

In relation to health outcomes, the most frequently explored interventions included access or proximity to greenspace and greenness (this includes exposure to combined green and blue spaces), urban greenspace and infrastructure, nature-based therapy (including green care and green prescription), physical activity and exercise interventions, contact with nature, density and quality of green space, and finally, access or exposure to blue spaces. Less prevalent interventions include the availability of parks, community gardens and gardening, and playgrounds, walkability and cycling routes.

Results:

Access or proximity to greenspace appeared as the most studied intervention identified in the literature. In the literature this is often referred to as 'greenness' exposure and commonly measured with proxy measures such as the NDVI.

Key relationships in the literature, supported by systematic and umbrella reviews, highlighted protective and positive relationships between greenness and contact with nature, and general overall health and well-being [6, 7, 29-31], and positive social benefits [7, 32]. As supported in the health chapter of the IPCC 6th Assessment Report Working Group II, there is high scientific confidence that access to greenspace is associated with well-being [6]. Positive relationships are also found in with exposure to combined blue and greenspaces [10, 33, 34].

According to several literature reviews (umbrella, systematic and narrative), greenness has also been associated with positive mental health outcomes [7, 31, 35], improved affect [36], as well as reduced risk of stress [7, 31, 32, 37], depression and anxiety [38], and psychosis [39]. A randomized, case-cross over study in Spain found that when compared to urban environments both greenspace (coefficient -4.78, 95% CI=-7.77 to -1.79, p<0.01) and blue space (coefficient -4.53, 95% CI=-7.57 to

-1.49, p<0.01) were found to be associated with a significant reduction in total mood disturbance [40]. However, it is important to note that the sample size of this study is small, consisting of 26 adults. Similarly, a longitudinal cohort study in Finland found an inverse association between residential greenness and depression risk in urban areas, based on residential greenness within a 100m radius, with those with higher residential greenness are 0.56 times less likely to experience depression (OR: 0.56; 95% CI 0.33 to 0.96) at 5-years follow-up, and 0.54 times less likely (OR: 0.54; 95% CI 0.30 to 0.98) after 14-years follow-up [41]. Gacson et al. [42] systematically reviewed the long-term mental health benefits of residential green and blue spaces. They found a causal relationship between adult mental health and greenness, with limited supporting evidence. However, there is insufficient evidence to establish a causal relationship for children [42]. Similarly, other studies have highlighted that there is currently insufficient evidence to establish a longitudinal causal relationship between greenness and health [43, 44].

Several reviews highlight the positive association between greenspace access and physical activity [7, 32, 36, 45-47]. To date, few studies have established a causal relationship [26, 47, 48]. This is partly due to a lack of standardisation of definitions and measures used in studies [49]. With regards to obesity, the results are more mixed. Some cross-sectional studies have established a positive relationship between neighbourhood greenspace and its accessibility, and reduced likelihood of being obese [50, 51]. For example, a cross-sectional study in a Dutch municipality found that improvements in neighbourhood environments were associated with lower odds of obesity among elderly, particularly low traffic nuisance (OR: 0.91; 95%CI: 0.84-0.98), and better access to green space (OR: 0.85; 95%CI: 0.73-0.97) [51]. Furthermore, a systematic review by Cronin et al [52] identified that lack of access to greenspace is a key mediating factor in higher risk of obesity among lower educated households. However, the remainder of studies, consisting primarily of systematic reviews found mixed or weak associations between obesity and various greenness proxy measures [35, 36, 44, 51, 53, 54].

Strong evidence (meta-analyses, and umbrella and systematic reviews) supports the relationship between greenness and reduced risk of all-cause mortality [8, 29, 55, 56]. A health impact assessment in Switzerland found consistent evidence that suggests that greenness in residential areas reduced the risk of mortality independently from other environmental exposures such as air pollution and noise related to transportation [57]. With regards to non-communicable diseases, strong evidence has been found supporting protective effect of greenspace access and exposure for multiple non-communicable disease outcomes such as atopic and respiratory diseases, type two diabetes, stroke, coronary heart disease, ischemic heart disease, and cardiovascular disease [10]. A meta-

analysis by Gascon et al [55] shows a significant association between increased greenness and lower risk of cardiovascular disease [risk ratio (95%CI)=0.96 (0.94,0.97), p-het=0.26] and all-cause mortality [risk ratio (95%CI)=0.92 (0.87, 0.97), p-het<0.001]. This finding is supported by a range of other studies [44, 58, 59]. However, with regards to cancer risks, the findings are varied. There is potential for greenspaces to be a risk factor for increased skin cancer [60]. Some protective effect has been found for both breast and prostate cancer [60]. Furthermore, some studies have found an increase in lung cancer associated with exposure to greenspace [60]. However, existing evidence is conflicting regarding the association between greenspace and the incidence of breast, lung, and prostate cancer [10, 55, 60].

As far as childhood and youth development goes, increased exposure NDVI has been associated with positive youth development and decreased emotional and behavioural difficulties in children, but no association or mixed evidence exists for cognitive and brain development, academic achievement and absenteeism, as well as social functioning and cognitive skills [35, 43]. Greenness has been associated with positive birth and pregnancy outcomes, particularly healthy birth weight, reduced risk of small size with regards to gestational age [29, 61] and higher likelihood of breastfeeding [62]. Furthermore, the WHO [7] attests that children are increasingly suffering from what is referred to as nature-deficit disorder as a result of growing disconnection from nature. A cross-sectional study of 9444 adults in Basel, Switzerland identified that life satisfaction varied according to age [63]. Specifically, living closer to a forest as opposed to a park or agricultural area, was associated with lower life satisfaction in the young adults aged 18–29 years. According to the authors of this study, this indicates differing perceptions of greenspace between younger and older people, and that perhaps younger people living further from city centres in greener areas feel more isolated. This suggests that access to greenspaces, particularly parks, are an important feature for healthy development and life satisfaction, however this may differ with age.

While several studies suggest the potential for increased asthma or allergy (such as allergic rhinitis) associated with the proximity of greenspaces, particularly in children [64], evidence has been mainly described as inconclusive due to conflicting findings [8, 10, 35]. For example, a pooled cohort study in Europe found that 10% increase in greenspace coverage was significantly associated with a 5.9% and 13.0% increase in the odds of wheezing, asthma, and allergic rhinitis among children [64]. Most recently, however, a systematic review and meta-analysis identified no significant association between NVDI and allergic rhinitis in children and adolescents [65].

Urban greenspace and urban green infrastructure

A positive association between urban greenspace and general overall positive health is supported by all relevant literature identified, including strong evidence in the form of numerous systematic reviews [6, 8, 10, 66-69]. In general, protective effects have been found with regards to all-cause mortality [17, 70]. A quantitative estimate of European cities in 2015 found that meeting the WHO recommendation of access to green space could prevent 42,968 (95% CI 32296–64177) deaths annually (when measured using an NDVI proxy) [17]. This represents 2.3% (95% CI 1.7-3.4) of natural-cause mortality and 245 (95% CI 184-366) years of life lost per 100,000 inhabitants per year [17]. In Zurich this corresponds to the prevention of 205 (155–306) years of life lost per 100 000 inhabitants (95% CI) [17]. Iungman et al [70] conducted a quantitative estimate for all-cause mortality for adults aged 20 years or older in 93 European cities. They found that approximately 2644 (95% CI 2444–2824) premature deaths due to Urban Heat Islands could be prevented by increasing city tree coverage to 30%. This corresponds to 1.84% (1.69–1.97) of all summer deaths and results in cooler city temperatures (mean reduction of 0.4°C; SD 0.2; range 0.0–1.3). Associations also exist with positive mental health outcomes in adults and children [8, 67, 68]. Within populations of older adults, urban greenspaces are associated with higher physical activity, but mixed results have been found in terms of depression [67]. Urban greenspaces and infrastructure have been identified as supportive for increased physical activity and reduced obesity by two reviews and a policy brief from the WHO [5, 7, 8]. In particular, the larger size of urban parks (as opposed to multiple smaller parks), perceived quality of the urban greenspace, and presence of facilities such as walking trails, cycling routes, water areas, and playgrounds have been identified as positively related to higher levels of physical activity [8].

Community gardens are small plots of land integrated in urban neighbourhoods which are managed collaboratively by collectives of residents or gardeners [71]. They offer a range of benefits to both individuals and communities, extending beyond just physical health [4]. Community garden participation has been found to contribute to a wide range of health outcomes, including reduced depression, anxiety, and body mass index, as well as increased life satisfaction, quality of life, and sense of community [72]. People are motivated to engage in gardening as the concrete and tangible goal of producing food, and the aesthetic experience of gardening, contribute to a sense of meaning, satisfaction, pride, and values among gardeners, which promotes feelings of well-being [73, 74]. Furthermore, community gardens promote social bonds and community involvement by offering spaces for individuals to interact with close ones and fellow gardeners [73-76]. These social and

emotional benefits, combined with physical activity and consumption of fresh, unprocessed food, are conducive to both physical and mental health.

Box 2. Community garden examples from European cities

The **'Tuinstraten'**[1] project **(Antwerp, Belgium)** aims to bring nature into built-up areas to adapt to climate change and improve the quality of life for vulnerable populations. Eight garden streets have been created in five districts, designed with collaboration from residents, and including green features such as trees, lawns, and vegetable gardens, reducing heat stress and improving drainage, and offering space for social interactions and outdoor activities.

'Orto Collettivo'[2] **(Genova, Italy)** converts abandoned urban land into a large fruit and vegetable gardens using permaculture methods, providing a common space for local residents to grow food sustainably while promoting outdoor activity and learning. The project involves a range of training activities, and volunteers from disadvantaged social groups, fostering social cohesion and promoting exchange between participants.

Created by the Edible Cities Network, the **urban community gardens**[3] promote urban food production in cities worldwide to create green businesses and promote social cohesion. The project in **Berlin, Germany** has developed community gardens in socially disadvantaged neighbourhoods, offering space for biodiversity, social interaction, and training, and a team of stakeholders worked collaboratively to create the spaces.

[1]For more information, see: [77]; [2] [78]; [3] [79]

Urban greenspaces have also been found to be supportive of child health and development [33, 67]. Additionally, research in Switzerland has suggested that urban greenspaces are important for social networks and inclusion for children and young people [8]. Finally, in France it was found that the use of anti-inflammatory sprays were higher in young children living in an urban areas following high pollution days compared to those living in areas surrounded by forest or national parks [80]. A narrative review by Kruize, van der Vliet [68] suggests that urban greenspaces may also contribute to improved immune function.

Box 3. Tree coverage in European Cities[1]

In the 38 cities covered by the European Environment Agency, the average tree cover is 30%, although the percentage varies significantly. Finnish and Norwegian cities have the most tree cover, with more than half of the city area covered, compared to cities with the least, with less than 10%. Tree cover in capital cities ranges from 4% in Nicosia to 72% in Oslo. Tree coverage in Bern is 53%, however urban parks and recreational greenspaces only cover 4% of the city[2].

[1]These statistics are drawn from an assessment by the European Environment Agency [33]; [2]Statistics available at European Environment Agency website [81].

Nature-based therapy and green care

With regards to overall health, two systematic reviews found a positive association between health and nature based therapies including interventions that most often involved adventure-based activities, walking and relaxation in natural environments [47, 82]. The majority of studies on nature-based therapy, green care, or green prescription demonstrate strong evidence supporting the mental health benefits of such interventions. All studies, except for one, identified positive impacts for mental health associated with various nature-based therapies. A systematic review and meta-analysis of randomised control trials identified that green exercise and nature based therapy are positively associated with reduced anxiety (Standard mean difference [SMD]: 0.94; 95% CI: 0.94 to 0.01) and negative affect (SMD: 0.52; 95% CI: 0.77 to 0.26), as well as improving depressive mood (SMD: 0.64; 95% CI: 1.05 to 0.23) and positive affect (SMD: 0.95; 95% CI: 0.59 to 1.31)[83]. Strong and recent evidence in the form of a recent systematic review and meta-analysis illustrates that 'green prescription' or 'nature prescription' (a recommendation from a health or social professional for a patient to spend a fixed amount of time in a natural setting) results in reduced anxiety and depression, reduced blood pressure, and increased daily step count of an average of 900 steps [84]. This meta-analysis identified a moderate reduction of depression with a standardised mean difference of –0.50 (ranging from –0.84 to –0.16) post-intervention, similarly moderate to large reductions in anxiety scores were identified post-intervention with a standardised mean difference of –0.57 (ranging from –1.12 to –0.03) [84]. Green care initiatives led to greater decreases in systolic blood pressure, with a mean difference of -4.82 mm Hg (-8.92 to -0.72) and diastolic blood pressure, with a mean difference of -3.82 mm Hg (-6.47 to -1.16) [84]. For patients with well-defined diseases, nature based therapy has been found to aid with decreasing psychiatric symptoms, anger, substance abuse, and craving and relapse, as well as improve outcomes for abstinence from drugs, mood and anxiety disorders, behavioural and personality disorders, acquired brain injury and youth delinquency [85]. These

reviews are supported by several non-randomised experimental studies which have identified the value of nature based therapy for reducing stress and improving psychological health [86], as well as reducing mental confusion, depression and improving mental state [87].

Physical activity and exercise interventions

Numerous studies evaluated the impact of physical activity and exercise interventions in greenspaces and their impact on various health outcomes. A positive association between outdoor activities in natural environments and overall health has been confirmed in a systematic review [47]. A systematic review of randomised control trials and quasi-experimental studies of exercise interventions (including walking, outdoor exercise regimes, outdoor training, outdoor resistance training, face to face counselling and coaching, brochures with physical exercise classes) in both blue and greenspaces found an overall indication of improvement in well-being, mood, and physical performance [88]. The design and size of playgrounds have been found to be important factors in the level of physical activity [24-26]. The presence of other active children in playgrounds has been identified as a main factor for encouraging moderate to vigorous physical activity in children [26]. While innovative playground design is associated with MVPA levels, playground size is more strongly linked to the number of visitors, and designing playgrounds for adults is as important as designing for children to increase visit hours [25].

Moderate and vigorous physical activity has been found to more likely take place in parks and fields compared to streets and other urban spaces [89, 90]. Walking in an urban street (Oxford Street) compared to an urban park (Hyde Park) resulted in higher respiratory symptoms (including cough, sputum, shortness of breath, and wheeze) among sufferers of chronic obstructive pulmonary disease [91]. Walking in the urban park facilitated improved respiratory function, however, these benefits were diminished when this was followed by a walk on the urban street. Similarly, a randomised control trial in Lithuania found that engaging in physical activity within a green environment with lower levels of noise and air pollution compared to urban environments has a more significant positive impact on the stress level and hemodynamic parameters of patients with coronary artery disease [92]. A randomised control trial comparing lunchtime walks in nature with walks in the built environment found that perceived mental health was improved for the nature walking group only [93]. Similarly, 10 minutes sitting or walking in nature, compared to walking or sitting in urban environments, was found to improve mental well-being in college students [94]. A randomized cross-over study in Spain found that short walks in blue spaces can have a positive impact on both mood and well-being [95], which is supported by literature reviews [83, 88]. Nevertheless, the authors of this study did not find any

evidence of blue spaces having a beneficial effect on any of the cardiovascular outcomes evaluated [95]. Nor were there significant associations found with exercise or self-esteem in children [90].

Access or exposure to blue space

Some studies dedicated to examining the health benefits of blue spaces demonstrate that there is evidence of associations between blue spaces and overall health [96, 97]. Others highlight that the heterogeneity of evidence makes it difficult to draw clear conclusions. Never the less, the balance of evidence suggests a positive association between health and blue spaces [98]. All studies examining blue space and mental health suggest a benefit with regards to overall mental health as well as reduced stress and mood disturbance [40, 98, 99]. Other associations identified in the literature include a positive association between blue space and physical activity [98]. Inadequate evidence exists to draw conclusions with regards to potential benefits for diabetes and cardiovascular disease [98].

Density and quality of greenspace

The evidence surrounding the density and quality of greenspace indicates that there is an overall positive association with multiple physical and mental health outcomes [7, 33, 100]. The perceived quality of greenspace, particularly biotic integrity (such as species richness and heterogeneity, and habitat heterogeneity), and pleasing aesthetic aspects of greenspaces, such as depth and lushness of greenery in parks, have been identified as important for self-reported health, reduced psychological distress and encouragement of physical activity. Increased physical activity and reduced risk of obesity has been found as being related to the quality of greenspace activity [7]. This is also demonstrated by a cross-sectional study of cities in Europe, including Geneva. Across the eight European cities studied, it was identified that Individuals living in areas with high greenness have 3.3 times the odds of engaging in physical activity compared to those living in areas with low greenness (OR: 3.32; 2.46 to 4.50; $p<0.001$) [101]. Furthermore, individuals living in areas with high greenness have 0.63 times the odds of obesity compared to those living in areas with low greenness [101].

This scoping review highlighted also an important limitation with regards to proxy measures for greenness. In particular, two spaces with the same NDVI or percentage of canopy coverage may in reality reflect very different levels of biodiversity, as well as vegetation and fauna compositions. Relying on these proxy measures presents major limitations in terms of the comparability of the diversity of greenspaces, their classification and their quality (particularly biodiversity).

Differing health benefits in specific populations

Within the studies that differentiate health outcomes with regards to population groups, it is evident that greenspaces bring significantly greater benefits for particular groups. Overall, research suggests that engaging with nature has a stronger protective effect on the physical health of individuals from low socioeconomic backgrounds and minority groups [8, 102]. In European cities, the amount of greenery in neighbourhoods varies, in general communities with lower socio-economic status have fewer and lower quality greenspaces [33]. A large cross-sectional study in Basel found that the association between residential greenness and life satisfaction varies based on age groups, household income, and financial concerns [63]. Within this context, residential greenness was positively associated with life satisfaction among those with high household income and fewer financial worries. A negative association was found between life satisfaction and residential greenness for those between 18 to 29 years of age and those with more financial concerns [63]. Limited access to natural greenspaces is associated with lower levels of physical activity, increased health complaints, and reduced life expectancy, particularly among those living in inner-city areas with lower socioeconomic status [7]. Having good access to greenspaces has been found to help to reduce the negative impact of socioeconomic inequality on mental well-being by 40% [103]. It is important to note that the relationship between access to natural environments and health outcomes is often confounded by socioeconomic factors, as people with higher incomes and social capital can afford to live in areas with more and better-quality greenspaces [7]. Several studies have found that proximity to natural environments has a stronger association with health outcomes among lower-income or less-educated groups, and that loss of biodiversity may disproportionately impact the health and well-being of the poorest [7]. Women in low-income groups may also benefit from nearby natural environments to better cope with stress [7]. Access to greenspaces is associated with improved mental health in women, and studies in Europe have found positive associations between access to nearby greenspace and reduced blood pressure and depression in pregnant women, with a stronger effect for reduced depression in disadvantaged groups [8]. With regards to physical activity, ethnic groups have been found to have lower levels of cycling and gardening compared to non-minority groups [104], while walking is generally increased with perceived safety for women and having a park was associated with longer time walking for men [105]. It has been reported that during COVID-19 there has been a general decrease in physical activity but an increase in the use of parks and trails [106].

3) What are the co-benefits of **contact with nature through greenspaces**?

Summary:

Environmental co-benefits and ecosystem services appeared in several scientific articles and grey literature reports (n=22). The primary co-benefits explored included biodiversity and immune function, roles in climate change adaptation, as well as ecosystem services such as reduction of air pollution, heat and noise, and the regulation of water run-off. Trade-offs for the health of ecosystems and humans were also raised in this literature, including vector borne disease, increased presence of allergens and risk of UV exposure, environmental exposure to chemicals such as pesticides, and the negative impact of human activity on natural spaces and species. To complement the identified literature, a previous literature review conducted by members of the research team was drawn upon [4, 14].

Results:

Greenspaces provide ecosystem services that are important for human health and well-being. While the pathways are complex and the results are somewhat mixed, greenspaces can serve important functions for air quality regulation [32, 66, 96]. On the one hand, trees and other plants can help mitigate air pollution by absorbing gases and particulate matter (PM) [32, 66]. However, they can also contribute to air pollution by releasing hydrocarbons and pollen [32]. Importantly, urban vegetation can contribute indirectly to climate change mitigation and improved air quality by providing passive cooling and thus reducing building energy demand [32]. It is well established that green and blue spaces have important roles in reducing the urban heat island affect and heat stress in general [6, 36, 66, 96, 107, 108]. Furthermore, they help to regulate water-runoff [6, 66] and vegetation (excluding deciduous vegetation) helps to attenuate noise [36, 66, 109].

Greenspaces and urban green infrastructure are important climate change mitigation and adaptation strategies. As an adaptation strategy, they help to address various climate hazards such as flooding, drought, heat and precipitation variability [6]. Such approaches can be implemented by national and local governments as a key response to climate change [6]. It is important to note that, as climate change continues to progress, loss of access to greenspace due to storm damage, drought, and wildfires is likely to increase, which will have negative impacts for human and ecosystem health [6].

Box 4. Examples of Urban Green Infrastructure as climate change responses in Switzerland[1]

Green roofs in Basel: combining climate change mitigation and adaptation[1]
Basel was the first city in the world to make greenspaces a legal requirement on new buildings. The city has the largest area of green roofs per capita in the world with 5.71 m^2 per inhabitant in 2019. The city has implemented various incentive programs since 1996 to increase green roof installation, which were initially driven by energy-saving purposes and later also for biodiversity conservation. In 2002, the Building and Construction Law was amended to mandate green roofs on all new and renovated flat roofs, with associated design guidelines, and this was reinforced in 2010 for all new flat roofs. In 2006, there were 1,711 extensive and 218 intensive green roofs in Basel, covering approximately 23% of flat roof area. Since then, around 100 green roofs covering 80,000 m^2 have been installed each year, and it is estimated that around 40% of roof surface is now covered by green roofs. These initiatives are expected to bring adaptation benefits in the form of lower temperatures and reduced surface runoff.

Combating the Urban Heat Islands in Geneva and Lausanne[2]
To counter the heat-island effect, improve air quality, retain soil water, and protect biodiversity, more greenery is being integrated into urban planning. Geneva and Lausanne have launched programs to finance the creation of green roofs and pocket parks to make room for nature and to counteract the effects of higher temperatures. Lausanne aims to extend its green canopy by increasing tree cover from 20% to 30% by 2040. In 2021, the city planted approximately 1,500 trees, and similar numbers were planned for 2022. Geneva plans to invest up to CHF 100 million over the next 15 years to meet its greening objectives.

[1]Additional information can be found at: [110] and [111]; [2] Information for these examples were drawn from the following sources: [112-114].

Urban green infrastructure and blue space regeneration can enhance ecological health and biodiversity [28, 30, 97, 100]. Biodiversity can contribute to human health in a variety of ways, such as through cultural and spiritual values, social connectedness, as well as healthy immune resilience and functioning [7, 14, 115-118].

It is important to note that green and blue spaces present potential public health risks such as increased risks for exposure to disease vectors and zoonotic diseases, allergens, algae, excessive UV exposure, environmental exposure to chemicals (such as pesticides) and drowning [6, 8, 29, 68]. Several studies in this review highlighted activity of disease vectors in parks and urban greenspaces

[119, 120] and included increased activity associated with climate change [6, 121]. Additionally, the increased, expanded or continued long-term use of greenspaces may present important trade-offs (negative impacts) for climate change (for example, due to greenhouse gas emissions if motorised transport is used to access greenspaces, and for the species that inhabit these natural spaces. For example, nature based recreation such as hiking, running, cycling, canoeing, wildlife viewing, horse riding and dog walking has been found to have a negative impact on bird populations [122]. In the alpine ecosystems of southwestern Switzerland, it has been found that disturbance by snow sport free-riders increases stress in black grouse, a declining bird species [123]. These findings show that human disturbance through the use of greenspaces can pose a serious threat to wildlife.

Synthesis of findings

Numerous relationships between green and blue spaces and behaviour change, health outcomes and co-benefits were identified through this scoping review focusing on literature primarily from European countries, including Switzerland. The primary relationships identified through the literature review are illustrated in Figure 2 and are summarised below.

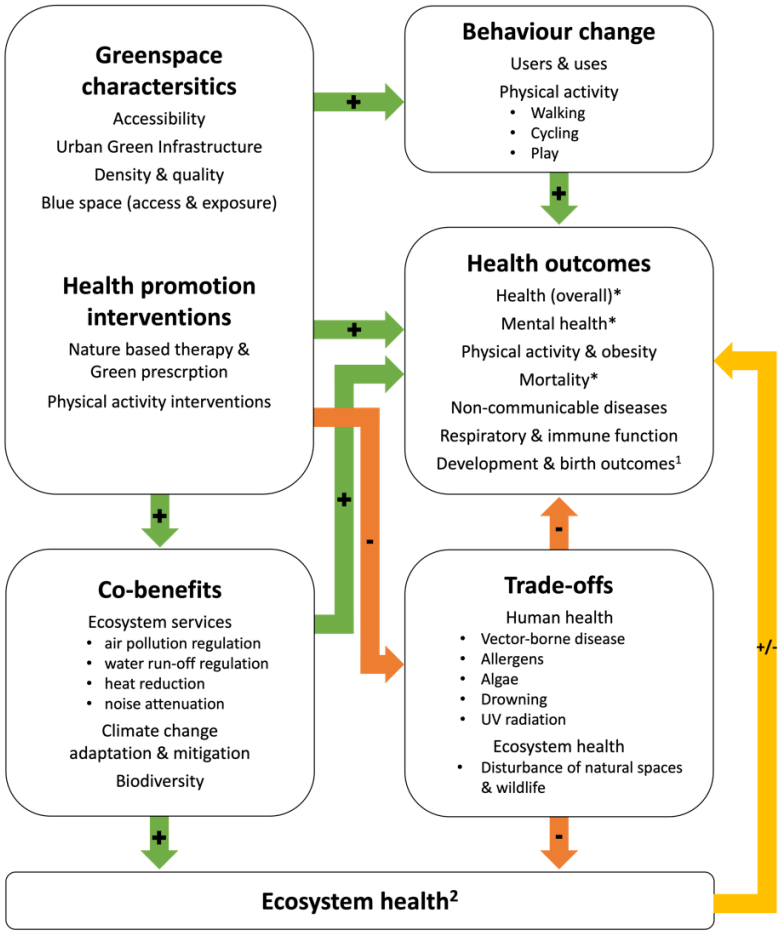

Figure 2. Main relationships between greenspaces, behaviour change, health outcomes and co-benefits

*Strong evidence exists for the relationship between greenspace and overall health, mental health and all-cause mortality
[1]No literature pertaining to blue space and development & birth outcomes was identified
[2]The direction of the association between ecosystem health and human health depends on the state of health of ecosystems, in general positive ecosystem health is linked to positive human health and negative ecosystem health is linked to negative human health

Only a small portion of academic and grey literature focuses on behaviour change related to greenspaces and health, it focuses primarily on park uses, users and physical activity. A Swiss study found that 75% and 36% of the Swiss population are within five minutes and 15 minutes respectively of urban greenspace, and 72% and 52% of the population are within five minutes and 15 minutes respectively of the nearest forest, if motorised transport is used [16]. However, it is important to note that accessing greenspaces by motorised transport does not facilitate health benefits associated with active mobility, and contributes to climate change through associated greenhouse gas emissions, thus creating a negative trade-off. For this reason, the WHO recommends that everyone live within 300m (approximately 5 minutes' walk) of public greenspaces of at least 5,000 to 10,000 Square Meters [5]. Having such access on foot to public greenspace has been found to potentially prevent 205 (155–306) years of life lost per 100 000 inhabitants in Zurich (95% CI) [17]. Public parks can serve as effective settings for interventions targeting youth to improve physical, mental, and emotional health outcomes [22]. Tailoring the design of playgrounds to include innovative designs, lendable sports material, and sports guidance in a safe environment, as well as promoting larger numbers of children to play, increases playground use and physical activity levels of youth in deprived neighbourhoods [24-26]. Neighbourhood walkability is positively associated with higher numbers of park visitors and mean activity levels of visitors [28]. Cyclists tend to select routes with more green and aquatic areas, avoiding main roads and crossings, and considering topography as a factor in their choice of route [27]. Regeneration and upkeep of blue spaces support changes toward healthier lifestyles and healthy urban environments [28]. Finally, contact with nature is suggested to improve sustainability-related behaviours [7], however further research is needed.

Within the literature included in this review, access and exposure to greenspaces is the most studied intervention for promoting health and well-being. Exposure to greenspaces has positive relationships with overall health, well-being, and social benefits [6, 7, 29-32]. This includes mental health outcomes, particularly reduced risk of stress, depression, and anxiety [7, 31, 32, 35-39], and physical health, with strong evidence to support the reduced risk of all-cause mortality [8, 29, 55, 56]. Additionally, greenspace has been identified as having protective effects for multiple non-communicable disease outcomes such as atopic and non-malignant respiratory diseases, type two diabetes, stroke, coronary heart disease, ischemic heart disease, and cardiovascular disease [44, 55, 58, 59]. Access to greenspaces has positive associations with physical activity, although few studies have established a causal relationship [7, 26, 32, 36, 45-48]. The relationship between greenspaces and obesity is mixed, but some studies suggest that lack of access to greenspaces is a key mediating factor in higher risk of obesity among lower educated households. Nature-based therapies, green care, or green prescription

are effective “activators” in improving mental health outcomes, reducing anxiety and depression, and improving overall health [47, 82-84]. Outdoor activities in natural environments and exercise interventions in greenspaces have a positive impact on well-being, mood, and physical activity [47, 84]. Access or exposure to blue space is associated with overall health benefits and positive mental health outcomes, such as reduced stress and mood disturbance. However current evidence indicates conflicting results, thus limiting the possibility to draw definitive conclusions with regards to potential benefits for diabetes and cardiovascular disease [40, 98, 99]. The density and quality of greenspace is associated with multiple physical and mental health outcomes, such as reduced psychological distress, increased physical activity, and reduced risk of obesity, particularly for individuals from low socioeconomic backgrounds and minority groups [7, 33, 100]. The health benefits of engaging with nature vary based on population groups, with lower-income or less-educated groups benefiting the most [7]. Furthermore, women and those in low education and income groups may gain the most benefit from nearby natural environments [8, 105].

Greenspaces provide essential ecosystem services that are important for human health and well-being, such as air quality regulation [32, 66, 96], heat reduction [6, 36, 66, 96, 107, 108], noise attenuation [36, 66, 109], and regulation of water runoff [6, 66]. Furthermore, they are important co-benefit strategies for climate change mitigation and adaptation that can help address various climate hazards [6]. Greenspaces create numerous co-benefits for the environment, such as enhancing ecological health and biodiversity [28, 30, 97, 100]. It is important to note, however, that they can also contribute to public health risks including through exposure to vector-borne disease, allergens, and UV radiation [6, 8, 68, 119-121]. Responsible governance, management and developing biodiverse greenspaces is imperative to minimize the impact of human disturbance through the use of greenspaces, which poses a serious threat to wildlife [122, 123].

Overall, greenspaces and contact with nature can help promote health and well-being while also bringing co-benefits for ecosystems and human health. Increasing access to greenspaces, particularly for individuals from low socioeconomic backgrounds and minority groups, can bring overall health, well-being, and social benefits. Policies should be developed to enhance the quality of greenspaces, particularly in deprived neighbourhoods, paying particular attention to walking trails, cycling tracks, innovative playground design, and safety of greenspaces. Innovative playground design can include incorporation of factors to promote physical activity (for example loose equipment, daily supervision during peak times with a designated sports coach to organise activities). In planning greenspace interventions, it is important to consider the specific context and that different greenspaces can elicit varying activity levels among different groups of users [18]. The development of health promotion initiatives to encourage outdoor activities in natural environments and exercise interventions are

particularly important to accompany physical activity and behaviour change. Within this context, it is important to develop nature-based therapies and green prescription ("activator interventions") that benefit overall health and mental health by improving access to greenspaces of individuals and populations. Additional weighting should be given to the co-benefits for ecosystem services, climate change adaptation and mitigation, biodiversity, and ecosystem health. However, responsible governance, management and use of greenspaces is crucial to minimize the public health risks and most importantly the impact of human disturbance of species and nature.

Further research would be necessary to aid public health decision-makers to distinguish between types of urban green infrastructure (e.g., street trees, parks, playgrounds, etc) and their particular effectiveness with regards to behaviour change and health benefits. Currently, there is limited research linking greenspaces, sustainable and pro-environmental behaviours and health outcomes. Furthermore, the proxy measures often employed in the identified studies (such as NDVI, percentage of canopy coverage, etc) present important limitations in terms of the comparability of the diversity and quality of greenspaces, how they are classified (particularly their biodiversity). For example, two spaces with the same NDVI or percentage of canopy coverage may in reality reflect very different levels of biodiversity, as well as vegetation and fauna compositions. Further studies should take special attention in better characterizing greenness and modalities of individual exposure. Finally, it is important to note that the restriction of the search criteria to studies relating to countries in Europe presents potential limitations in terms of the inclusion or exclusion of some literature. The authors sought to overcome this challenge by also drawing on key sources of international literature from the WHO and IPCC.

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Appendix 1 – Search Strategy

Key search terms

Topic	Key search terms
Review focus	
2. Green and blue spaces	Green space, greenspace, greening, greenness, parks, nature area, urban nature, urban garden, community garden, green infrastructure, biodiversity, forest, national park, field, one health, urban agriculture, community garden, urban farming, garden, permaculture, vegetation, landscape, built environment, bluespace, blue space, blue infrastructure
Outcome:	
a) impacts on behavioural change	Mobility behaviour change, Health behaviour change, pro-environmental behaviour, health promoting behaviour, healthy behaviour, physical activity
b) impact on physical and mental health	Physical health, cardiovascular disease, type 2 diabetes, obesity, cancer, mental health, anxiety, depression, stress, hypertension, well-being, wellness, trauma, injury, pulmonary diseases, asthma, allergies (immune diseases)
c) environmental co-benefits relating to biodiversity and climate change	co-benefits, cobenefits, biodiversity, human nature contact, nature, climate change, greenhouse gas emissions, air pollution, soil pollution

An example of the search syntax used for PubMed is shown below.

("Biodiversity"[Majr:NoExp] OR "Built Environment"[Mesh:NoExp] OR “Forests”[Mesh] OR “Gardening”[Mesh] OR “Gardens”[Mesh] OR “Nature”[Majr] OR "Parks, Recreational"[Majr] OR "green space*"[tiab] OR “greenspace*”[tiab] OR “green area*”[tiab] OR “green infrastructure*”[tiab] OR "garden*"[ti] OR “permaculture”[tiab] OR “Trees”[Mesh] OR "biodivers*"[ti] OR "park"[tiab] OR "parkland"[tiab] OR "parks"[tiab] OR “blue infrastructure*”[tiab] OR “blue space*”[tiab] OR “bluespace*”[tiab] OR “greenery”[tiab] OR “greening”[tiab] OR “greenness”[tiab] OR “open space*”[tiab] OR "forest*"[ti] OR "urban nature"[tiab] OR "natural environment"[tiab] OR "nature"[ti])

AND
(“Health behavior”[Mesh] OR ”health-related behavio*”[ti] OR “healthy behavio*”[ti] OR “behavior change*”[ti] OR “behaviour change*”[ti] OR “environmental awareness”[ti] OR “health behavio*”[ti] OR “health promoting behavio*”[ti] OR “mobility behaviour change”[ti] OR “multiple behavio*”[ti] OR “multiple health behavio*”[ti] OR “pro-environmental behavio*”[ti] OR “proenvironmental behavio*”[ti] OR “Leisure Activities”[Mesh:NoExp] OR “leisure activit*”[ti] OR "Sports"[Mesh:NoExp] OR “sport*”[tiab] OR “running”[tiab] OR “walk”[tiab] OR “walking”[tiab] OR “smoking”[tiab] OR "social connect*"[tiab] OR "Social Cohesion"[Mesh] OR "social cohesion"[tiab] OR “Social skills”[Mesh] OR “social skills”[tiab] OR “prosocial behavio*”[tiab] OR “active lifestyle”[tiab] OR “Sleep”[Mesh] OR “sleep”[tiab] OR “Exercise”[Mesh] OR “exercise*”[ti] OR “physical activit*”[tiab] OR “Diet”[Mesh:NoExp] OR “diet”[tiab] OR “eating”[tiab] OR “nutrition”[tiab] OR "Feeding Behavior"[Mesh])

AND

("Health"[MeSH] OR "Health Status"[MeSH:NoExp] OR “health” [ti] OR "Chronic Disease"[MeSH] OR "Disease"[MeSH] OR "disease*"[ti] OR "Mental Disorders"[MeSH] OR "mental well-being"[tiab] OR "mental wellbeing"[tiab] OR “mental illness”[tiab] OR "psychiatric disorders"[tiab] OR "anxiet*"[tiab] OR "depress*"[tiab] OR "mood*"[tiab] OR “psychological wellbeing”[tiab] OR “psychological well-being”[tiab] OR “emotional well-being”[tiab] OR “emotional wellbeing”[tiab] OR "morbidity"[tiab] OR "mortality"[tiab] OR "Morbidity"[MeSH:noexp] OR "Mortality"[MeSH:noexp] OR "birth outcome*"[tiab] “pregnancy”[tiab] OR "Pregnancy Outcome"[Mesh:NoExp] OR "allerg*"[tiab] OR "rhinitis, allergic, seasonal"[MeSH] OR "Allergy and Immunology"[MeSH:NoExp] OR "asthma*"[tiab] OR "Body Mass Index"[MeSH] OR "Body Mass Index"[tiab] OR "Obesity"[Majr] OR "obesi*"[tiab] OR "Quality of life"[MeSH Terms] OR "quality of life"[tiab] OR "cancer"[ti] OR "diabet*"[ti] OR "cardiovascular"[tiab] OR "Blood Pressure"[tiab] OR "Blood Pressure"[MeSH:NoExp])

AND

("Europe"[Mesh] OR Europe*[tiab] OR Andorra[tiab] OR Austria*[tiab] OR Balkan[tiab] OR Belgium[tiab] OR Britain[tiab] OR Danish[tiab] OR Denmark[tiab] OR England[tiab] OR Finland[tiab] OR France[tiab] OR French[tiab] OR German*[tiab] OR Gibraltar[tiab] OR "United Kingdom"[tiab] OR Greece[tiab] OR Iceland[tiab] OR Ireland[tiab] OR Italy[tiab] OR Liechtenstein[tiab] OR Luxembourg[tiab] OR "Mediterranean Region"[tiab] OR Monaco[tiab] OR Netherlands[tiab] OR "Nordic Countries"[tiab] OR Norway[tiab] OR Portug*[tiab] OR "San Marino"[tiab] OR Scandinavia* OR Spain[tiab] OR Spanish[tiab] OR Sweden OR Swiss[tiab] OR Switzerland[tiab] OR Transcaucasia[tiab] OR Vatican[tiab])

Appendix 2 – Inclusion and exclusion criteria

Inclusion criteria	**Exclusion criteria**
Peer-reviewed academic articles including: • Research studies with various design, interventional and observational (e.g. randomised control trials, case-control studies, pre-post studies, observational studies) • Modelling studies linking to health and at least one of the two focus areas • Literature reviews articles of all types	Expert commentaries and non-empirical academic articles, case reports
Grey literature from reputable international organisations in relevant domains including: WHO, IPCC, IUCN, IPBES, UN Habitat, UNEP, European Environment Agency.	Modelling studies not linking to health
Policy recommendations and guidelines when available	Non-peer reviewed publications including conference proceedings.
Published since 2000	Articles not written in French and English
Switzerland (in particular for illustrative case studies and examples) and Europe	
Focus of the literature is on behavioural change, health impacts and environmental co-benefits of mobility infrastructure and/or greenspaces and parks	