Superior
Health Council

GREEN AND BLUE CITIES: NATURE AND HUMAN HEALTH IN AN URBAN SETTING

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Superior Health Council

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Green and blue cities: nature and human health in an urban setting

This scientific advisory report synthesizes current knowledge and on-going Belgian research on the linkages between nature and human health, aiming to assist in promoting beneficial interactions while minimising detrimental ones.

The report provides policy-makers and other societal groups with recommendations stemming from the field of medicine, urban planning and ecology.

This version was validated by the Board on
6 October 2021[1]

EXECUTIVE SUMMARY

For many years, fostering human health and preventing disease focused on adequate medical care, a balanced diet, sufficient food, clean air and clean water. However, humans are part of a natural ecosystem, the adequate functioning of which is essential for human health. The interlinkages between nature and human health are variable and complex, and their understanding is still underway. However, there is increasing evidence for the importance of these interlinkages, with respect to both benefits and risks for human health.

This advisory report of the Superior Health Council aims at putting the knowledge into practice and at promoting beneficial interactions between nature and human health while mitigating detrimental ones. Given the scope and complexity of the subject, and the extremely high degree of urbanization of the Belgian territory, the Council concentrates in this report on the specific topic of the effects of nature on human health in the urban setting.

The report is based on a review of the scientific literature published in both scientific journals and peer reviewed reports from competent national and international organizations, on the opinion of the experts of the ad hoc working group that prepared the report, and includes the outcomes of a consultation of Belgian scientists working on nature-human health linkages (with an inventory of relevant Belgian scientific publications). As the Belgian context is rarely addressed in international knowledge overviews, the Council deemed it necessary to incorporate relevant Belgian knowledge emerging from recent and ongoing Belgian research on nature and human health interlinkages. The field is still relatively young in Belgium, but developing rapidly.

To develop a policy- and practice-relevant advisory report, the Council aimed to tailor relevant knowledge on nature and human health in an urban setting to policy and practice in the spatial planning and primary human healthcare sectors, as these sectors were considered key end-users for uptake of the Council's recommendations. Therefore, a selection of Belgian practice experts was also consulted.

[1] The Council reserves the right to make minor typographical amendments to this document at any time. On the other hand, amendments that alter its content are automatically included in an erratum. In this case, a new version of the advisory report is issued.

The evidence collected in the reviewed international scientific overview reports displays a broad diversity of benefits of urban nature to physical and mental human health, but also addresses nature related human health risks, in particular infectious diseases. The Council chose to mainly focus on the key environmental, health and social aspects. Furthermore, the Council studied existing explanatory mechanistic hypotheses. These explanatory frameworks are not mutually exclusive and illustrate the complexity of nature and human health interlinkages.

Conceptually the health of an individual is the result of genetic traits and the way one is exposed to and able to cope with external influences. However, the simplicity of this concept is deceptive. First, genetic traits change in the course of life through aging processes and by the interaction with external determinants. Also, external determinants are a complex interplay of biophysical factors, the availability of food and water, economic, social and cultural norms and pressures, and learning processes. More and more it is being realized that human health – individually and collectively – depends on processes occurring within social-ecological systems.

Nature-health interlinkages in urban settings operate within these social-ecological systems. Given the complexity of urban areas, i.e. urban social-ecological systems, despite a rapid increase in the numbers and diversity of relevant scientific studies, it will not come as a surprise that uncertainties and unknowns remain in the scientific knowledge about these interlinkages. Further research will resolve some of these knowledge gaps, but the Council stipulates that the inherent complexity of urban areas, also in terms of their development over time, results in inherent uncertainties and unknowns.

Notwithstanding this, the Council concludes from the available data that there is ample room for improvement of health by accounting for nature-health interlinkages, in parallel to the ongoing development of scientific understanding. This improvement results from increasing the health benefits as well as reducing the negative health impacts. These improvements could also go beyond human health and reach urban species and ecosystems. Therefore, the Council proposes to use the available knowledge in local, national and international governance to further health. Unfortunately, there is no standard recipe for transforming urban areas in order to further health in its broadest sense: 'greening and blueing' cities might play a key role, but how this can take place concretely depends on the specificities of an area. Each urban area has its own specific natural, social, cultural and economic characteristics. A stepwise approach to transforming urban areas with the purpose of improving health may help identify and predict how this will pan out – or not – in a given context, with its own specificities, and provide lessons for further developments.

So following a stepwise, adaptive policy for transforming the urban area into one with better prospects for human, animal, plant and ecosystem health is recommended. Given the inherent complexity of social-ecological systems, such as urban areas, assessing the result of policy measures and the actions taken by governments, private organizations and citizen groups is seldom unambiguous, also because different groups may have different preferences or stakes. This warrants an inclusive deliberative approach. Health in itself is an unmeasurable concept, so indicators are necessary. The Council strongly advises to thoroughly monitor results using an appropriate set of indicators through a continuous process of health policy impact assessment. A prudent, step-by-step approach not only avoids following irreversible and/or ineffective pathways but also serves as a feedback to science for enhanced understanding and incorporation of new insights regarding unforeseen complexities.

Key recommendations:

- Support mainstreaming the interlinkages between urban green and blue space and human health through all levels of society.
- Support expanding and strengthening transdisciplinary and multisectoral frameworks such as One Health and EcoHealth.
- Support cointegration of biodiversity and human health into all levels of governance.

- Support the transparency, monitoring and implementation of current knowledge.
- Support the development of more resilient and effective human health systems that integrate human healthcare and environmental care.
- Support measures which foster human health equity.
- Support the inclusion of the human health effects of urban green and blue space into spatial planning and urban development plans, while taking into account local needs and also inform citizens about biological risks involved in nature contact.
- Support longitudinal, transdisciplinary research projects in which both human health benefits and risks of urban green and blue space are investigated in an integrated way.
- Support detailed research on the linkage between human immune system and natural environment .
- Support practice-oriented and collaborative research.

Keywords and MeSH descriptor terms[2]

MeSH terms*	Keywords	Sleutelwoorden	Mots clés	Schlüsselwörter
-	nature-human health linkages	connecties tussen natuur en menselijke gezondheid	liens entre l'environnement et la santé humaine	Wechselwirkungen zwischen Umwelt und menschlicher Gesundheit.
'biodiversity'	biodiversity	biodiversiteit	biodiversité	Biodiversität
-	urban areas	stedelijke gebieden	zones urbaines	städtische Gebiete
'cities'	cities	steden	villes	Städte
-	social-ecological systems	sociaal-ecologische systemen	systèmes socio-écologiques	sozial-ökologische Systeme
-	urban green and blue spaces	stedelijke groene en blauwe ruimtes	espaces verts et bleus urbains	urbane Grün- und Blauflächen
-	spatial planning	ruimtelijke planning	aménagement du territoire	Raumplanung
'primary health care'	primary human healthcare	eerstelijnsgezondheidszorg	soins de première ligne	primäre Gesundheitsversorgung

MeSH (Medical Subject Headings) is the NLM (National Library of Medicine) controlled vocabulary thesaurus used for indexing articles for PubMed http://www.ncbi.nlm.nih.gov/mesh.

[2] The Council wishes to clarify that the MeSH terms and keywords are used for referencing purposes as well as to provide an easy definition of the scope of the advisory report. For more information, see the section entitled "methodology".

CONTENTS

ABBREVIATIONS

ART	Attention Restoration Theory
B@SEBALL	Biodiversity at School Environments Benefits for ALL
BEOH	Belgian One Health network
CBD	Convention on Biological Diversity
COVID-19	Coronavirus disease 2019
ICD-10	International Statistical Classification of Diseases and Related Health Problems – version 10
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
NAMED	Nature impact on Mental health Distribution
NHI	nature and human health interlinkages
PM10	particulate matter < 10µm
SARS-CoV-2	Severe acute respiratory syndrome Coronavirus 2
SES	socio-economic status
SHC	Superior Health Council
SRT	Stress Recovery Theory
UGBS	urban green and blue space
URHIS	Urban Health Indicators System
UV	ultraviolet
VOC	volatile organic compound
WHO	World Health Organization

I. INTRODUCTION AND ISSUES

1. Why this report

For many years, fostering human health and preventing disease focused on adequate medical care, a balanced diet, sufficient food, clean air and clean water. However, humans are part of a natural ecosystem and the adequate functioning of this global ecosystem is essential for human health. The interlinkages between nature and human health (NHI) are variable and complex (WHO-CBD, 2015; IPBES, 2018), and their understanding is still underway. There is increasing evidence for the importance of these interlinkages, with respect to both benefits and risks for human health.

Internationally, the relationship between nature and human health is gaining attention in scientific research, in policy circles, professional sectors and in society at large (Millennium Ecosystem Assessment, 2005; WHO-CBD, 2015; Whitmee et al., 2015; IPBES, 2018). There is a need for more integrated approaches to fully grasp all relevant interlinkages in the complex relationship between nature and human health and to translate this understanding into operational knowledge. There are still challenges to address for NHI to play a mature role in policy and practice both internationally and in Belgium. Still, scientific studies have accumulated knowledge to an extent that warrants attention.

This advisory report of the Superior Health Council (SHC) aims to contribute putting the state-of-the-art available knowledge into practice and to promote beneficial interactions between nature and human health while mitigating detrimental ones. Given the scope and complexity of the subject, and the extremely high degree of urbanization of the Belgian territory, the Council concentrates in this report on the specific topic of the effects of nature on human health in the urban setting. Nature in this context may refer to landscape elements such as trees, vegetated areas, parks, woods, canals, moats, rivers, ponds, lakes and any living organism therein.

COVID-19

The present report was in progress when the lockdown was imposed in Belgium and many other countries worldwide due to the COVID-19 (Coronavirus disease 2019) pandemic. Given the restrictions on public mobility, in particular in urban regions, the question arises as to what role contacts with nature play in the public health effects of the COVID-19 pandemic. But also, this pandemic in itself is an illustration of NHI. The Council distinguishes three NHI relevant aspects: emergence, diffusion and public health measures. If an animal origin is confirmed – as suggested by, among others, Andersen (2020) and still assessed as the most likely scenario by the World Health Organization (WHO, 2021) – the emergence of SARS-CoV-2 (Severe acute respiratory syndrome Coronavirus 2) could be considered an illustration of how encroachment of human activities into natural habitats can lead to spillovers. Forest encroached by cropland, intensive livestock rearing, urban growth,… any human activity affecting the environment, including conservation, can be considered through the lens of pathogen dynamics and evolution.

Haider et al. (2020) propose not to classify COVID-19 as a zoonosis, but rather as an *"emerging infectious disease of probable animal origin"*. The many tens of millions human COVID-19 infections reported internationally appear to be exclusively through human-human transmission. This diffusion, facilitated by extensive global travel and the urban context, should also question our understanding of the fragilities of human health in a globalized world. These topics are outside the scope of this report and will not be further elaborated.

Finally, the lockdown adopted in Belgium as well as in other countries, during which outdoor physical activity was encouraged, highlighted the role of human health benefits from nature recreation facilities in the urban context and the challenge of accessibility for many urban households. In situations where visits to natural surroundings were still possible or even stimulated,

an increase in visits was observed as shown by a public survey during the first COVID-19 wave in Flanders (Lenaerts et al., 2021). People also reported a positive effect on human health and well-being. In situations where such visits were restricted, people looked forward to using parks and other natural surroundings, as shown by the increase in visits after the relief of lockdown restrictions. This highlights the need to account for social differences in options for nature contact. The least deprived often live in single family dwellings with gardens and thus enjoy natural surroundings even when confined to their homes. In preparation for future pandemics, policies should plan for socially equal access to natural surroundings (Slater et al., 2020), including for human healthcare workers who during a pandemic have to perform their tasks under severe pressure.

2. Questions and framing

The report focuses on the population living in urban areas, here understood to denote municipalities with centres with 50 000 inhabitants or more (Eurostat, 2013). It considers linkages between nature and human health in urban areas distinguishing:

- nature within a city;
- nature at the fringes of the city or further away in the so-called commuting zone.

In considering the linkages between nature and human health, the report will take into account the diversity and differences in vulnerability and resilience of the population living in urban areas. Relevant determinants, among other things, are age, gender, culture and socio-economic background.

The report:

- builds on scientific overview reports from international expert groups regarding evidence for beneficial and harmful effects associated to nature on the individual and public health in urban areas;
- discusses to which extent this evidence is relevant for people living in urban areas in Belgium[3];
- reviews ongoing research and existing expertise in Belgium.

Based on this review and discussion, the report will:

- recommend elements for urban spatial planning that foster public health and will limit damaging human health effects of nature within the urban areas in Belgium;
- recommend policies to strengthen equitable distribution of such benefits for human health over social groups and to support human healthcare professionals in fostering positive human health effects of nature and limiting damaging human health effects in urban areas in Belgium;
- recommend environmental policies to develop and maintain nature outside urban areas in Belgium in order to foster individual and public health of the people living in nearby urban areas;
- recommend priorities for scientific research aimed at fostering public health and limiting detrimental human health effects of nature within urban areas in Belgium;
- identify elements of nature that support human health and which may be included in healthcare and practice.

Framing of human health and nature

In this section several concepts playing an important role in the report are presented. This concerns health, and also specifically mental health and stress, primary healthcare, nature and the integrative concept of One Health.

[3] EUROSTAT/DG URBA identify 46 predominantly urban (rural population < 20 %) and 330 intermediate (rural population between 20 and 50 %) municipalities in Belgium (Eurostat, 2020).

Human health

In several scientific publications and policy documents, in particular in the domain of environmental health, human health is defined with reference to the WHO constitution as (WHO, 1946):

> *Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.*

In 2010, The Netherlands Organisation for Health Research and Development and the Health Council of the Netherlands convened an international meeting on the concept of human health (Huber, 2011). While not aiming to replace the definition of the WHO by a more comprehensive definition of human health, the meeting emphasized the dynamic character of human health:

> *Just as environmental scientists describe the health of the earth as the capacity of a complex system to maintain a stable environment within a relatively narrow range, […] we propose the formulation of health as the ability to adapt and to self-manage.*

The Council endorses this elaboration of the WHO definition within the framework of the present report.

Mental health

According to the WHO (2014), mental health is *"a state of well-being in which an individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and is able to make a contribution to his or her community"*. The Eklipse[4] systematic review (Beute et al. 2020a, b) focuses on a wide range of mental health aspects in order to identify mental health and well-being outcomes. These include a range from momentary mood to suicide rates, diverse categories such as general mental health, acute and direct effects on momentary mood, stress, and mental fatigue, retrospective reporting of momentary mood, prevalence and severity of mental health problems and specific correlates of mental health. Beute et al. (2020a, b) adhered to the ICD-10 (International Statistical Classification of Diseases and Related Health Problems – version 10) mental health classification system (WHO, 1992):

- affective disorders, stress-related diseases;
- schizophrenia, psychosis, paranoia;
- personality disorders;
- disorders of psychological development;
- cognitive dysfunction;
- neurodegenerative disease;
- problem behaviour.

Definition of stress

Charmandari et al. (2005) define stress as a state of threatened or perceived as threatened homeostasis. The human body and mind react to stress by activating a complex repertoire of physiologic and behavioural central nervous system and peripheral adaptive responses. If inadequate or excessive and/or prolonged, these may affect personality development and behaviour and may have adverse consequences on physiologic functions, such as growth, metabolism, circulation, reproduction and the inflammatory/immune response (Charmandari et al., 2005).

Definition of primary healthcare

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Primary healthcare is an important component of human healthcare. According to the WHO (1978): *"Primary healthcare is essential healthcare based on practical, scientifically sound and socially acceptable methods and technology made universally accessible to individuals and families in the community through their full participation and at a cost that the community and country can afford to maintain at every stage of their development in the spirit of self-reliance and self-determination. It forms an integral part both of the country's health system, of which it is the central function and main focus, and of the overall social and economic development of the community. It is the first level of contact of individuals, the family and community with the national health system bringing healthcare as close as possible to where people live and work, and constitutes the first element of a continuing healthcare process."*

Definition of nature

Nature refers to the environment in which organisms or their biotopes expressly manifest themselves. In addition to nature reserves, this also includes organisms and biotopes that spontaneously occur in farmland, production forest, urban green spaces and back gardens (Health Council of the Netherlands and Dutch Advisory Council for Research on Spatial Planning, 2004). The common denominator the present report uses to refer to these environments is 'green space'. Here we include in this concept of nature explicitly 'blue' nature, such as pools, ponds, lakes, rivers and the sea. The concept is broad and covers nature in or at the fringes of urban areas. Throughout this report, the SHC will denote these nature elements by 'urban green and blue space' or UGBS for short.

Definition of One Health

To grasp all relevant aspects of nature and health (human and other) interlinkages, several integrative perspectives on nature and health have emerged in recent years. This is prominently driven by emerging infectious diseases, rapid increases of non-communicable diseases, rising morbidity due to ecosystem and climatic changes and increased awareness of challenges of use of synthetic chemicals in human health, cropping and livestock farming such as antibiotics, fertilisers, pesticides and urban densification (Kruize et al. 2019). Several broad frameworks have arisen from these perspectives, such as One Health, EcoHealth, planetary health, global health, conservation health, biodiversity and health, agrihealth and health pluralism. The WHO's and the Convention on Biological Diversity's (CBD) state-of-knowledge review on biodiversity and health (2015) proposed One Health as an overarching framework for integrated efforts, while also recognizing and relating to other relevant approaches, such as EcoHealth. Earlier, a tripartite collaboration among the UN Food and Agriculture Organization, the World Organization for Animal Health and the WHO (Anonymous, 2010) proposed a similar integrated effort, also called One Health. The Lancet Commission on planetary health, another effort to document and assemble knowledge on *"human health and the state of the natural systems on which it depends"* (Whitmee et al., 2015), also highlights the integrated nature of human health in what they call Planetary Health.

EcoHealth encompasses ecosystem approaches to health: it encompasses the biological, physical, social and economic environments and their relation to human health (Lebel, 2003). One Health also began by trying to cover a variety of expertise, stemming mainly from the health and veterinary sciences, but over time it broadened its perspective to the human and natural environment (Rüegg, 2018). Zinsstag et al. (2011) proposed One Health as an approach aimed at tackling complex patterns of global change, in which the inextricable interconnection of humans, pet animals, livestock and wildlife health to their social and ecological environment is evident and requires integrated approaches.

Currently, the concept of One Health is becoming more prominent in global and national governance. In 2018, it was supported by the governments being member of the CBD (CBD, 2018): "*[…] invites Parties and other Governments to consider integrating One Health policies, plans or*

projects, and other holistic approaches in their national biodiversity strategies and action plans, and, as appropriate, national health plans." In the recent IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) workshop report on biodiversity and pandemics (IPBES, 2020) One Health is also proposed as a guiding concept. In Belgium it is a leading concept for the Federal Ministry for Health, Food Safety and the Environment and it was mentioned as one of the ambitions in the policy declaration of several current Belgian Ministers (e.g. Vandenbroucke, 2020; Khattabi, 2020; Clarinval, 2020). One Health also is a leading concept for the federal research institute Sciensano, which together with the Belgian Biodiversity platform, took the initiative to launch the Belgian One Health (BEOH) network at the end of 2019 (BEOH, 2019). This builds on the need for further networking and capacity building regarding One Health (Keune et al., 2017). BEOH brings together a wide diversity of Belgian organizations and actors working on aspects of One Health (Keune et al., 2021).

Nature and health interlinkages: key topical issues and mechanisms

The mechanisms underlying links between UGBS and access to UGBS on the one hand and human health on the other are likely to be complex and interacting and can result in human health benefits and risks (IPBES, 2018; WHO, 2016). In Figure 1 (Marselle, 2021) nature-health interlinkages are depicted, with biodiversity being used when referring to nature, and (human) health and human well-being as an overarching term including human health as used in this report. This overview figure includes many of the elements that will be dealt with in this advisory text, including diverse pathways, a wide array of moderating factors and interlinkages between all elements in the overview.

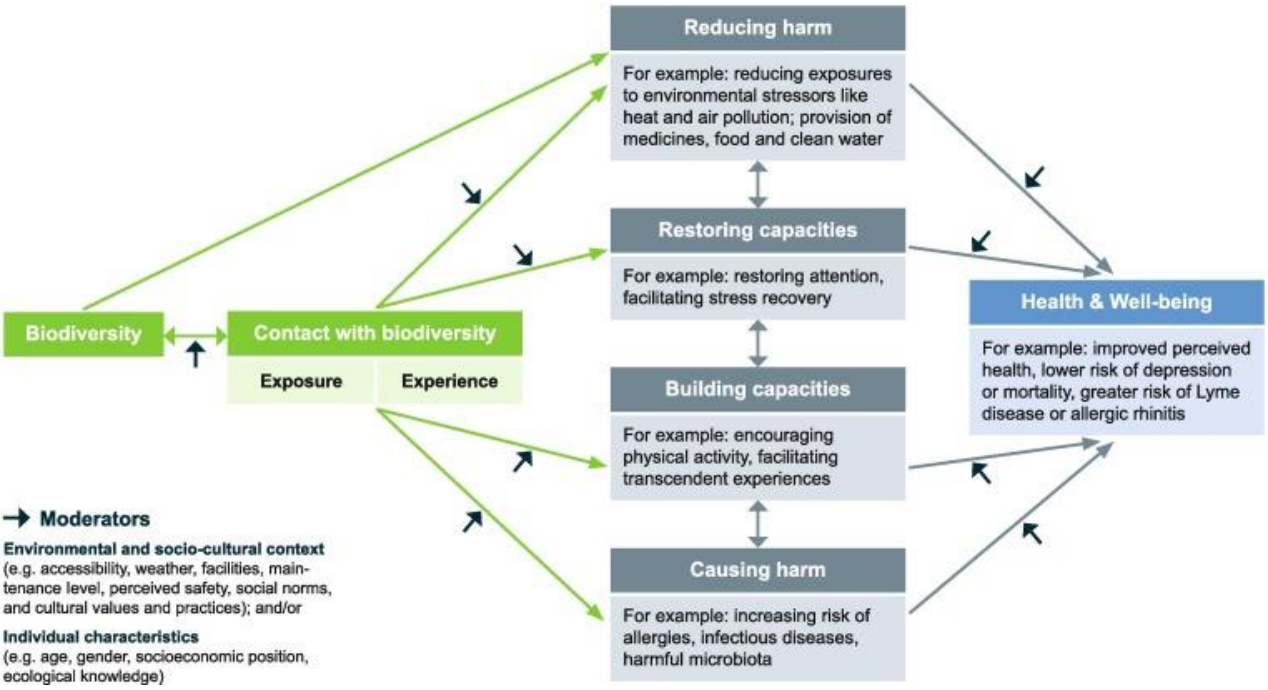

Figure 1. Nature/biodiversity-human health linkages (Marselle et al,. 2021). "Pathways linking biodiversity to human health and well-being. Four domains of pathways linking biodiversity and health involve contact with biodiversity (i.e. exposure and possibly experience). An additional pathway runs directly through the reducing harm domain, which implies that biodiversity may affect health without an individual or group having contact with biodiversity (e.g. biodiversity improving upstream water quality through bioremediation). Each domain may be related with all others (for ease of presentation, only adjacent relationships are shown). Two-headed arrows between the domains speak to the potential for reciprocal relationships. Associations between variables are subject to modification by the environmental and socio-cultural context or individual characteristics."

This report focuses on benefits and risks for human health emanating from nature in Belgian urban areas. UGBS and access to UGBS affect human health through various pathways, some of which may interact.

II. METHODOLOGICAL APPROACH

The initiative for this report was taken in the standing working group on chemical agents. This group historically mainly focussed on environmental issues concerning chemical pollutants, but over time has developed a broader view on environmental health, including natural elements.

After analysing the project proposal, the Board, the chair of the domain chemical agents and the chair of the ad hoc working group identified the necessary fields of expertise. An ad hoc working group was then set up which included experts in various fields related to health, nature, environment, social aspects and spatial planning. The experts of this working group provided a general and an ad hoc declaration of interests and the Committee on Deontology assessed the potential risk of conflicts of interest.

This advisory report is based on a review of the scientific literature published in both scientific journals and peer reviewed reports from competent national and international organizations, on the opinion of the experts of the ad hoc working group, and includes the outcomes of a consultation of Belgian scientists working on nature-human health linkages (with an inventory of relevant Belgian scientific publications), as well as representatives of the spatial planning sector and the primary healthcare sector.

Once the advisory report was endorsed by the *ad hoc* working group and by the standing working group chemical agents it was ultimately validated by the Board.

The method used in compiling the present report entails three approaches:

1. international literature review;
2. consultation of Belgian research;
3. consultation of Belgian practice.

1. International literature review

Scientific publications on the relationship between nature and human health have increased in number and scope over the last decade. A systematic review of all published literature was beyond the resources of the ad hoc group that drafted the report. It is primarily based on existing scientific literature overview reports from international expert groups linked to international organizations and initiatives such as WHO, CBD, IPBES, EKLIPSE, EU, who have themselves reviewed the existing literature. A list of the review reports from which information was drawn is given in Table 1.

Table 1. Reviews with information on the relationship between nature and human health.

Year	Reference
2015	WHO-CBD, Romanelli C, Cooper D, Campbell-Lendrum D, Maiero M, Karesh WB, Hunter D *et al.* Connecting Global Priorities: Biodiversity and Human Health. A State of Knowledge Review. Geneva: World Health Organization, Secretariat of the Convention on Biological Diversity; 2015. Internet: https://www.cbd.int/health/SOK-biodiversity-en.pdf.
2015	Whitmee S, Haines A, Beyrer C, Boltz F, Capon AG, de Souza Dias BF *et al.* Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. Lancet 2015;386(10007):1973-2028, doi:10.1016/S0140-6736(15)60901-1
2016	WHO-Europe. Egorov Andrey I, Mudu P, Braubach M, Martuzzi M, editors. Urban green spaces and health - a review of evidence. Copenhagen: WHO Regional Office for Europe; 2016. http://www.euro.who.int/en/health-topics/environment-and-health/urban-health/publications/2016/urban-green-spaces-and-health-a-review-of-evidence-2016
2016	ten Brink P, Mutafoglu K, Schweitzer J-P, Kettunen M, Twigger-Ross C, Kuipers Y *et al.* The Health and Social Benefits of Nature and Biodiversity Protection. London/Brussels: Institute for European Environmental Policy; 2016. A report for the European Commission (ENV.B.3/ETU/2014/0039). https://ieep.eu/publications/new-study-on-the-health-and-social-benefits-of-biodiversity-and-nature-protection
2017	WHO-Europe. Urban Green Space Interventions and Health. A review of impacts and effectiveness. Copenhagen: WHO Regional Office for Europe; 2017. http://www.euro.who.int/__data/assets/pdf_file/0010/337690/FULL-REPORT-for-LLP.pdf.
2017	CBD. Report of the regional workshop on The interlinkages between human health and biodiversity for the European Region (Helsinki, 23-26 Oktober 2017). Montreal, Canada: Secretariat of the Convention on Biological Diversity; 2017 November 24. Document CBD/HB/WS/2017/1/2. https://www.cbd.int/doc/c/ab6d/0fed/3e795d2f62d288b6ee369c31/hbws-2017-01-02-en.pdf
2018	IPBES. Fischer M, Rounsevell M, Torre-Marin Rando A, Mader A, Church A, ElbakidzeE M, et al., editors. Summary for policymakers of the regional assessment report on biodiversity and ecosystem services for Europe and Central Asia of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Keune H., Kretsch C., Oosterbroek B. Appendix 2.8. Bonn: IPBES secretariat, Bonn; 2018. Internet: https://ipbes.net/system/tdf/eca_ch_2_appendix_2.8_assessment_of_health.pdf?file=1&type=node&id=16593
2020	Beute, F., Andreucci, M.B., Lammel, A., Davies, Z., Glanville, J., Keune, H., Marselle, M., O'Brien, L.A., Olszewska-Guizzo, A., Remmen, R., Russo, A., & de Vries, S. (2020a) Types and characteristics of urban and peri-urban green spaces having an impact on human mental health and wellbeing. EKLIPSE report https://eklipse.eu/wp-content/uploads/website_db/Request/Mental_Health/EKLIPSE_HealthReport-Green_Final-v2-Digital.pdf
2020	Beute, F., Davies, Z., de Vries, S., Lammel, A., Glanville, J., Keune, H., Marselle, M., O'Brien, L.A., Olszewska-Guizzo, A., Remmen, R., Russo, A., & Andreucci, M.B. (2020b) Types and characteristics of urban and peri-urban blue spaces having an impact on human mental health and wellbeing. EKLIPSE report https://eklipse.eu/wp-content/uploads/website_db/Request/Mental_Health/EKLIPSE_Health-BlueReport-Appendix_Digital.pdf

As the relationship between nature and human health potentially covers a broad range of scientific expertise, the collection of information from international scientific literature overview reports was shared and assessed within the ad hoc working group by means of an expert elicitation process. As start of the elicitation, synthesized findings from the review reports were presented to the ad hoc working group members, as well as draft recommendations, in order to get a common knowledge base and focussed discussions in the group. This elicitation formed the basis of a first overview of key findings from the international literature and draft key recommendations.

2. Consultation of Belgian science

The Belgian context is rarely addressed specifically in international knowledge overviews. Therefore, the Council thought it was necessary to incorporate relevant Belgian knowledge emerging from recent and ongoing Belgian NHI research. The field is still relatively young in Belgium, but is developing rapidly. The ad hoc working group developed an overview of relevant Belgian research groups, projects and publications. Based on this overview, the ad hoc working group consulted Belgian researchers during the first half of 2020 via an online survey to which 19 experts from Belgian science, policy and practice responded (overview in Acknowledgements). The survey included questions regarding:

- type of projects, publications, nature-human health linkage knowledge produced;
- views on draft key recommendations that resulted from the expert elicitation procedure within the ad hoc working group;
- scientific advice based on the outcomes of their research for practical implementation and for policy support, especially geared at the spatial planning sector and the primary healthcare sector;
- identified knowledge gaps and obstacles to research, including funding, on nature-human health linkages in Belgium.

3. Consultation of Belgian practice

To develop a policy- and practice-relevant advisory report, the Council aimed to tailor relevant knowledge on nature and human health in an urban setting to policy and practice in the spatial planning and primary human healthcare sectors, as these sectors were considered key end-users for uptake of recommendations from the report. Next to consultation of Belgian scientists, the ad hoc committee also consulted a selection of Belgian practice experts.

For the Flemish region, available recent and unpublished interviews on nature-human health linkages with representatives of mainly the human healthcare sector, but also from the spatial planning and nature sector (University of Antwerp Chair Care and the Natural Environment project *Licht op Groen*), were complemented with interviews with representatives of the spatial planning sector. For the Brussels-Capital region, several representatives of the spatial planning and human healthcare sector were interviewed. For the Walloon region, a consultation among public administrations and experts was performed through a questionnaire survey.

III. ELABORATION AND ARGUMENTATION

1. Key aspects and mechanisms

Fout! Verwijzingsbron niet gevonden.**1.1 Evidence from international scientific literature overview reports**

Nature & human health linkages

The evidence collected in the international scientific overview reports reviewed in this report (table 1) displays a broad diversity of simultaneous benefits of urban nature to physical and mental human health, but also addresses nature related human health risks, in particular infectious diseases. NHI are increasingly acknowledged in different scientific fields including health sciences, psychology, biology, spatial planning and design, social sciences and environmental sciences. The Council chooses to focus on the key aspects depicted in Figure 2.

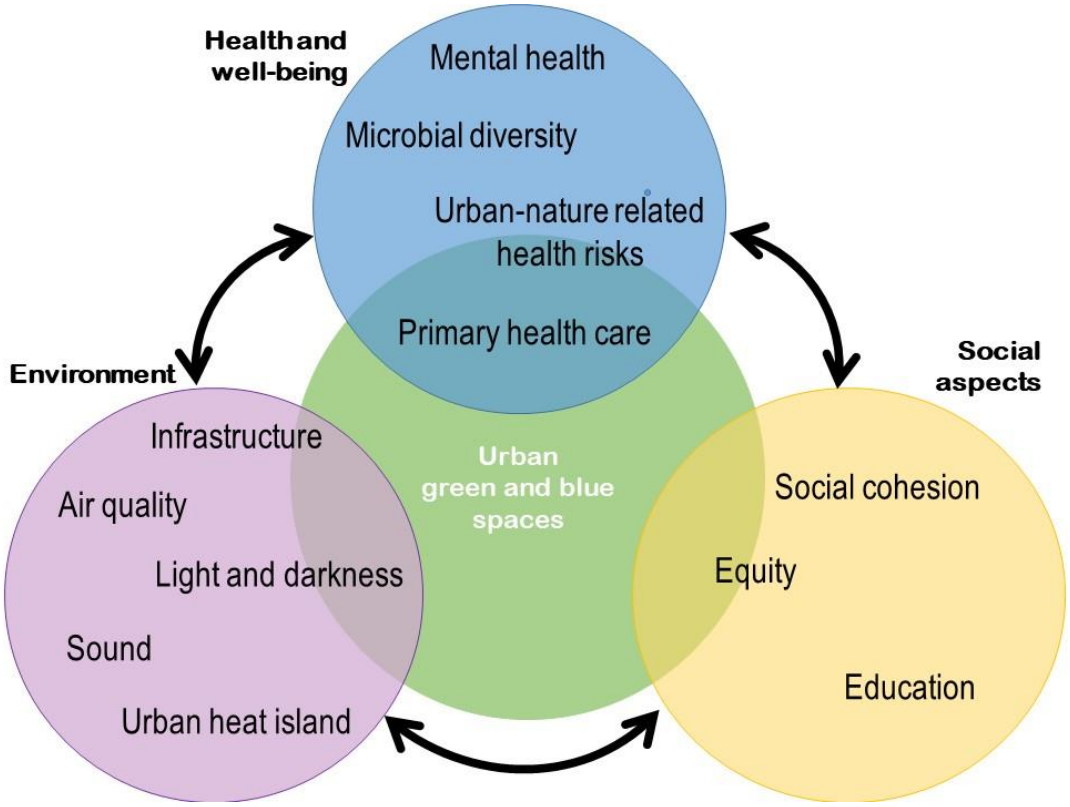

Figure 2. Overview of NHI key aspects in relation to UBGS.

Below, knowledge and aspects related to the topical issues are described, including elements from international and from Belgian research.

1.1.1 Environmental aspects

Infrastructure

Larger areas of UBGS, well connected with smaller patches of nature, may be most beneficial for human well-being by offering safe opportunities for active mobility and sports as well as for stress recovery, recreation and social contact. Such a widespread, connected UBGS is also likely to increase urban resilience to extreme environmental events, such as heat waves, by mitigating the urban heat island effect and by providing better cooling capacity (Ten Brink et al., 2016), or such as the effects of extreme rainfall, by reducing surface run-off (WHO, 2016). Smaller UBGS and views on UBGS are also valuable, e.g. for mental health (Hartig et al., 2014).

The WHO (2016) and Ten Brink et al. (2016) recommend that everyone should have accessible natural green spaces of various sizes at various distances from home. As human health outcomes of nature interventions are context-specific (WHO-CBD, 2015), it is recommended to plan and design nature together with the target group. Perceptions of the quality of green spaces may motivate behaviours more than the actual levels of available green space (Ten Brink et al., 2016). Further, accessibility of nature is considered important (including distance to green space and transportation options), as are potential other aspects such as perceived safety and cleanness, playground features or a community garden (Ten Brink et al., 2016). Qualitative aspects have been suggested to be of added value (WHO, 2016; Ten Brink et al., 2016; McEachan et al., 2018), such as size (WHO-CBD, 2015; WHO, 2016), presence of blue space (WHO, 2016; IPBES, 2018), land cover type, including grass or woodland (WHO, 2016), biodiversity (WHO-CBD, 2015; Ten Brink et al., 2016; WHO, 2016) and features for sports and recreation (WHO, 2016; Ten Brink et al., 2016).

An additional aspect to be taken into account when planning urban green space is the potential effect on nature related health risks. In a recent study (VanAcker, 2019) it was found that urban landscape connectivity can in fact lead to enhancement of risk for Lyme disease: forested parks with vegetated buffers and increased connectivity had higher nymph tick densities and the degree of park connectivity strongly affected *B. burgdorferi* infection prevalence in nymph ticks. The study challenges the perspective that tick-borne disease risk is restricted to suburban and natural settings and emphasizes the need to understand how green space design affects vector and host communities also in areas of emerging urban tick-borne disease. Other examples that are worth mentioning are allergies, exposure to pesticides, crime and drowning (WHO, 2016; Gascon et al., 2017).

For Belgium, research results confirm health benefits of nearby green space. Bijnens et al. (2015) found maternal residential proximity to traffic and lower residential greenness to be associated with shorter placental telomere length at birth (a sign of biological ageing). This may explain adverse health outcomes starting from early life, since shortened telomeres accelerate the progression of many diseases. Further, both Bijnens et al. (2017) and Madhloum et al. (2019) found indications that higher residential greenness was associated with lower blood pressure. Bauwelinck et al. (2018) showed that the number of green patches within an area has a strong beneficial effect on health. Bauwelinck et al. (2021) also showed that living in urban areas with more green space is associated with lower mortality risk.

However, not all Belgian studies confirm these positive health relationships unambiguously. Health being multifactorial, and exposure to infrastructure hard to measure on a large scale, disentangling the role of green infrastructure amongst other factors can be challenging. Aerts et al. (2020c) demonstrated that green space near the place where people live has protective effects on mental health (distress) of tree pollen allergy patients during the tree pollen season, but the same patients experienced stress when they knew that allergenic species such as birch, alder or hazel grew near their house. Aerts et al. (2020b) showed socio-economic deprivation to be a stronger predictor of cardiovascular medication prescription than green spaces (which had a protective effect on

medication sales). Trabelsi et al. (2019) found that in Belgium, the geographical distribution of purchases of prescribed asthma medication for pre-schoolers is only weakly correlated with some environmental factors (among which, green space). The existence of clear differences in prevalence of purchase between Flanders and Wallonia suggests that the observed geographical distribution is strongly driven by regional differences in medical practice. Based on an analysis of medication sales for childhood asthma, Aerts et al. (2020a) conclude that living in close proximity to areas with high grass cover (grasslands, but also residential gardens) may negatively impact child respiratory health.

Regarding Lyme disease risks, the important role for green space characteristics as well as measures of connectivity to known source areas is confirmed by Heylen et al. (2019) for Antwerp, as is depicted in Figure 3 below.

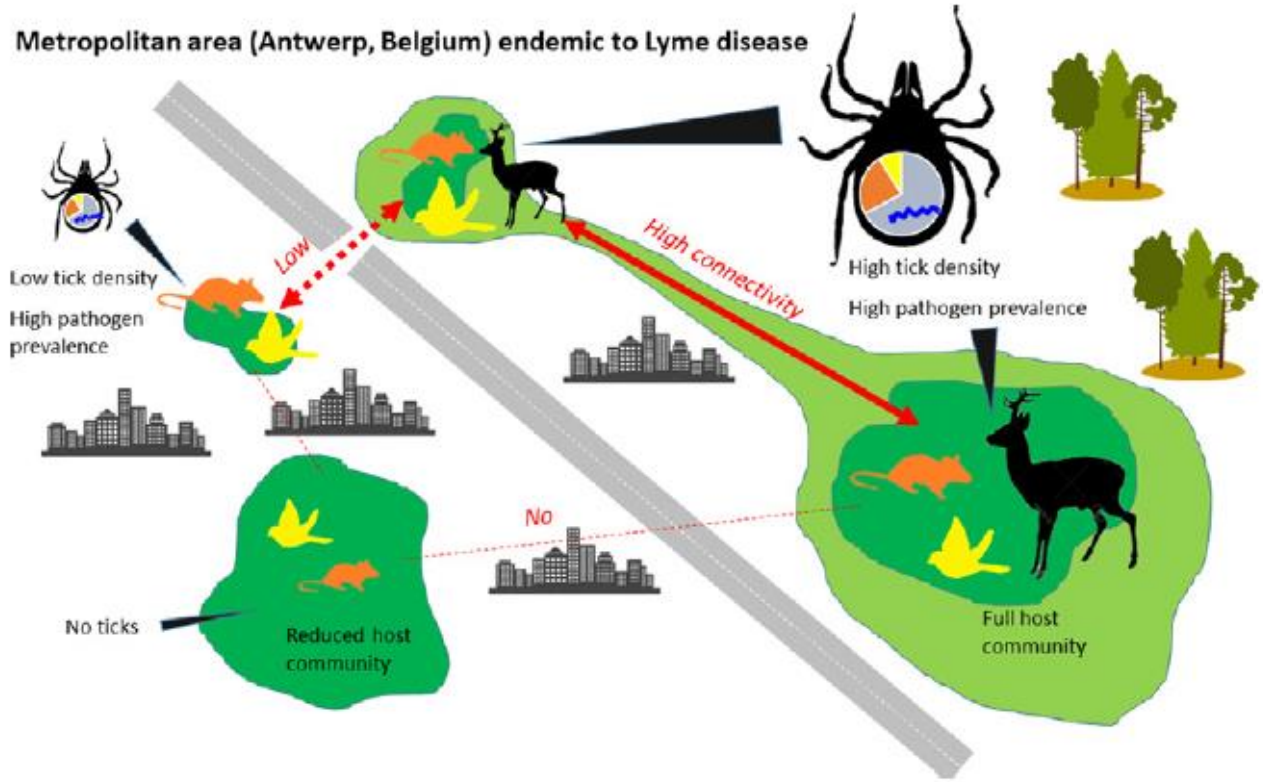

Figure 3. Illustration of Lyme disease risks in relation to green space characteristics and connectivity to known source areas (Heylen et al., 2019).

Integrated attention for both nature related health risks & benefits has been advocated more and more in recent years, internationally (Vanwambeke et al., 2019; IPBES, 2018) and in Belgium (Keune et al., 2013, 2017).

Air Quality

Associations between nature and improved air quality are widely investigated, but also still widely debated, with no clear-cut solid evidence base. In the UK, trees in the built environment have been found to remove up to 50 tonnes of air pollutants each year (Ten Brink et al., 2016). Removals of (locally) up to 40 % of nitrogendioxide and 60 % of particulate matter by vegetation have been reported (Ten Brink et al., 2016). Some specific urban setting, such as street canyons, may present complex interactions between emissions, air flow dynamics (desirable to disperse pollutants) and vegetation (as air "cleaner" and obstacle to air flow) (Ten Brink et al., 2016).

Up to now, three pathways have been identified by which nature improves air quality: (1) by modifying meteorological and microclimatic patterns, (2) by deposition and absorption of pollutants, including particulate matter and volatile organic compounds (VOCs) (WHO-CBD, 2015; Ten Brink et al., 2016). Beside the "cleaning" effect of vegetation, it can also improve air quality (3) by emission of oxygen and absorption of carbon dioxide. It should be noted that nature can also release volatile organic compounds resulting from various physical and biological processes such as nitrogen oxide and methane. The effectiveness of green spaces for absorption and deposition depends on a large number of variables. For instance, the type of vegetation (Ten Brink et al., 2016), local airflows (Ten Brink et al., 2016), street shapes, pollutant concentrations and plant positioning (Ten Brink et al., 2016) may all play a role. Additionally, nature can encourage citizens to use active mobility means which can reduce air pollutants, noise and unwanted light (Ten Brink et al., 2016).

A recent Belgian study of mental health effects of air pollution, noise and green space in Brussels (Pelgrims et al., 2021) demonstrated that exposure to air pollution was positively associated with depressive disorders, whereas the authors could not find clear relations with green space. Hooyberg et al. (2020) could identify air pollution (PM_{10} [5]) to be lower closer to coastal blue space, but this could not be statistically significantly associated with better health. Multicollinearity between air pollution and socio-economic variables across Belgium complicates the interpretation of effects of air pollution on health in a national model (e.g. Aerts et al., 2020b).

Urban heat islands

Temperatures in urban heat islands (an urban area or metropolitan area that is significantly warmer than its surrounding rural areas due to human activities) might be decreased by nature through providing shade and through evapotranspiration (Ten Brink et al., 2016). A 10 % increase in nature might keep the maximum temperatures by 2080 near the same level as the 1961-1990 conditions and might mitigate an expected temperature rise of 4 °C (Ten Brink et al., 2016). Other research found that an urban park could be 1 °C cooler than a non-green site (Ten Brink et al., 2016; WHO, 2016). Separately, blue infrastructures have been shown to contribute to reducing microclimatic temperatures, including air temperatures at night (Ten Brink et al., 2016). Other factors affecting the degree of cooling include the configuration, size, density and type of vegetation (Ten Brink et al., 2016; WHO, 2017). Recent research shows that a lack of vegetation and a high degree of imperviousness are associated with a higher risk of heat-related mortality in the Paris region (Pascal et al., 2021). More research is needed to establish clearly that a decrease in urban heat islands is to be expected depending on local specificities and UBGS characteristics, but the consequences of urban heat islands on health and the potential of UBGS is clear.

[5] 'PM_{10} – particulates with an aerodynamic diameter of less than 10µm.

Leuven.cool is a recent example of a Belgian study that investigates the impacts of urban green on local urban climate and thermal comfort, but as it has only recently been initiated, no relevant results are available yet.

Sound

There is evidence that vegetation can reduce noise exposure and its negative perceptions (WHO, 2017; WHO, 2016; Ten Brink et al., 2016). Vegetation reduces sound levels directly through the absorption, diffusion and transmission of sound energy (Ten Brink et al., 2016). By making the soil porous and soft, vegetation decreases especially low-frequency noise (Ten Brink et al., 2016). Green spaces that are effective in reducing road traffic noise include tree belts, vegetation on sound barriers, green walls and roofs, and parks (Ten Brink et al., 2016).

The way that sound at a specific location is perceived strongly determines its effects. This perception might be mediated or moderated by the greenness of a place. The multidimensional concept of the soundscape has been defined as all the sounds emanating from a landscape and encompasses the integration of biological, geophysical and anthropogenic sounds (Pijanowski et al., 2011). Depending on the associations of natural sounds, they are found to impact sound perception and emotional state (Ten Brink et al., 2016; WHO, 2016). For example, sounds from birds and water elements may reduce perceived loudness of road traffic noise and enhance the pleasantness and eventfulness of the soundscape (Ten Brink et al., 2016; WHO, 2016).

In their study of mental health effects of air pollution, noise and green space in Brussels, Pelgrims et al. (2021) could not demonstrate a significant association between noise from multiple sources and mental health. The authors underline the difficulty, when including many potential explanatory variables and confounders, to identify effects of a single one, as this may lead to an underestimation of the effect.

Light and darkness

Urban nature may encourage citizens to be more outdoors, leading to more exposure to sunlight, which is essential for natural circadian cycles (WHO, 2016; WHO-CBD, 2015). These are vital for multiple human health functions including metabolism and rest, which are of major importance in maintaining lower stress levels and good mental health status (WHO, 2016). It has been suggested that people living in greener neighbourhoods have lower risk on insufficient sleep (WHO, 2016). Moreover, elderly people who engage in outdoor activities have significant higher levels of vitamin D (WHO, 2016). Vitamin D is essential for numerous human health functions (WHO, 2016). It is also suggested that UV (ultraviolet) induced release of nitric oxide from the skin may have unforeseen human health benefits, including lowering the incidence of hypertension and cardiovascular disease (WHO, 2016). However, in summer and more southern areas, exposure to UV radiation should be restricted to decrease the risk on adverse skin conditions and in particular skin cancer. Vice versa, the increase in light from artificial sources during the evening and the night may disturb circadian cycles (SHC, 2016).

No relevant Belgian studies were identified.

1.1.2 Health aspects

Mental Health

The strongest positive effects of nature on human health and well-being appear to concern mental health, although mental and physical health are linked inextricably (IPBES, 2018; Ten Brink et al., 2016; WHO, 2016). The more time people are exposed to nature, the better their mood and well-being, partly through the reduction of stress (Ten Brink et al., 2016; WHO, 2016; WHO, 2017; Bratman, 2019). Access to nature has been associated with a reduced risk of poor mental health in women who are already physically active (WHO, 2016). In children, nature contact may benefit multiple factors of behaviour including cognitive functioning (Ten Brink et al., 2016). Urban green space may also benefit mental health on the long-term (Ten Brink et al., 2016; WHO, 2016). Moreover, physical activity in nature has been found to be of added value in reducing poor mental health (Ten Brink et al., 2016; WHO, 2016).

The EKLIPSE project systematically reviewed the effects of specific types and characteristics of urban and peri-urban blue spaces on mental health and well-being (Beute, 2020a; Beute, 2020b). No firm conclusions regarding mental health and well-being effects of specific types and characteristics of urban and peri-urban blue spaces could be drawn. The EKLIPSE systematic review on those associations (Beute, 2020a) did find enough scientific studies to confirm findings on the mental health benefits of green spaces, for all types of green space considered in the literature. Yet, the review could not identify clear-cut, generalizable findings regarding specific types and characteristics of urban and peri-urban green space. The extensive review could not find a gold standard for a particular green space type or characteristic working best for everyone, everywhere, and at every time. This heterogeneity may result from differences in exposure duration, in experiences (see also Bratman, 2019), and among target groups. This would lead to recommend a variety in green space types to capture all potential users, needs, and activities.

In Belgium several studies have investigated linkages between green and/or blue spaces and mental health. These studies present diverse outcomes, not always in line with international research findings. Outcomes regarding mental health appear sensitive to differences in methodological approaches. The Belgian project NAMED (Nature impact on Mental health Distribution), that studied the mental health effects of air pollution, noise, and green space in Brussels with both a qualitative and a quantitative study, highlighted this important methodological point (Lauwers et al., 2020). A qualitative walking interview investigation in Brussels highlighted the importance of green space next to other factors regarding the mental health effects of the quality of the living environment (Lauwers et al., 2021). Green-blue spaces were considered important to improve mental well-being by almost all participants but for different reasons: to meet people, to exercise, to walk, to relax, to reflect, to break the routine, to connect to nature, to get fresh air, to find peace, to get rid of concerns, to rebuild energy. The most common response was the feeling of “being away” from the city hustle and daily routines. The favourite place of half of the interviewees was linked to green-blue infrastructure. Different characteristics improving green-blue space experiences were mentioned: adaptations to various ages such as benches and flat soils for elderly, and secured playgrounds and toilets for children. Structural diversity was also mentioned, such as the presence of artistic features, flowers, and fountains. Some interviewees preferred large parks and others enclosed intimate parks for the feeling of being away. Not all parks were experienced positively in relation to mental well-being due to trash accumulation, overpopulation, or car disturbance.

However, in the NAMED project, quantitative analysis (Pelgrims et al., 2021) on the expected benefits of green space for mental health yielded statistically non-significant results. Different reasons may explain this. First, despite the attempt to use vegetation data at different levels (residence, street, and neighbourhood) and of various sources, other characteristics of public and private green spaces may contribute to more specific results. Trabelsi (2020) showed that the strength of the association between green exposure and mental health outcome could differ

depending on the green assessment measure used. Second, the type and the quality of the urban green space was not taken into account. Yet, according to other studies, biodiversity, accessibility, and social safety can be considered important factors that may influence the use of green spaces and might drive health outcomes. Several studies (reviewed in Beute, 2020a) show that, from a mental health perspective, the quality of public green spaces within a neighbourhood could play a more important role compared to quantity. Also, the high unequal distribution of green space, e.g. in Brussels, might be a factor that requires further research, especially because it has been shown (see studies reviewed in Beute, 2020a) that health benefits of access to green space may depend on socio-economic status.

Similarly, also other Belgian studies were unable to demonstrate the expected benefits of green (or blue) space for mental health. Van Herzele and de Vries (2012) did not find significant results regarding mental health either (only on general well-being: people living in a greener neighbourhood felt significantly happier). Hooyberg et al. (2020) could not demonstrate mental health benefits of coastal blue space. One study found diverging associations of residential green space with mental health in tree pollen allergy patients in Flanders: high levels of residential green space may protect against the development of short term emotional distress, but negative expectations regarding exposure to allergenic tree species in the living environment of tree pollen allergy patients may affect mental health through self-amplifying effects on allergic symptoms and distress (Aerts et al., 2020c).

Overall these conclusions underline the current need to establish clearer hypothesised causal effects of UGBS on mental health and, in relation to that, to identify clearer methodological standards for characterising those spaces.

Microbial Diversity

Contact with diverse environmental microbiota is increasingly believed to be one of the most likely mechanisms for various NHI (WHO-CBD, 2015; WHO, 2016; IPBES, 2018). Causal links may involve the functioning of the immune system through physical contact with nature (WHO, 2016; WHO-CBD, 2015). However, modern lifestyles in urban areas restrict contact with environmental and, subsequently, microbial diversity. Restricted contacts with microbial diversity is associated with a rise in the incidence of food allergies (WHO-CBD, 2015), hay fever and asthma, poor control of inflammation, cancers (WHO-CBD, 2015), obesity, cardiovascular disease, metabolic syndrome, type 2 diabetes (WHO-CBD, 2015), risk on autoimmune diseases, eczema, and depression (WHO-CBD, 2015). Growing up in rural and microbe-rich environments, where closer contacts with the environment is more straightforward, could reduce the development of allergies or atopy (Ten Brink et al., 2016), partly by obtaining components of our microbiome from soil and animals (WHO-CBD, 2015). The availability of nature and rich biodiversity in the direct living environment can decrease the prevalence of many widespread diseases (WHO-CBD, 2015; WHO, 2016). Families with lower socio-economic status (SES) might have fewer opportunities for lifestyle factors that contribute to maintaining essential microbiota communities, including variety in diet, access to gardens, and means to travel (WHO-CBD, 2015). A recent Finnish study showed that biodiversity intervention enhances immune regulation and health-associated commensal microbiota among day care children (Roslund, 2020).

No relevant Belgian studies were identified. Nevertheless, Belgian research regarding the human microbiome is generally developing rapidly. It started recently in the field of NHI, with projects such as the B@SEBALL (Biodiversity at School Environments Benefits for ALL) project (B@SEBALL, in progress), which investigates the beneficial health effect of microbial nature contact at green school playgrounds.

Urban nature related health risks

Nature, including urban nature, can provide a habitat for pathogen vectors such as mosquitoes and ticks, as well as toxin-producing organisms such as algae and bacteria, and various mammals that may carry pathogens (Keune et al., 2013). Other health risk examples that can be mentioned are exposure to allergens, to pesticides, to crime, and drowning (WHO, 2016; Gascon et al., 2017). Vanwambeke et al. (2019) illustrate how some nature related infectious diseases previously restricted to forests, became fully reliant on the urban and peri-urban environment such as dengue. Key processes relevant here can be identified as changes in the type and distribution of resources, in species composition, in contact rates, and in stress, all of which can be associated to increases, as well as decreases, in pathogen circulation. Urban growth has drawn a lot of attention, and so have the benefits of 'greening' urban areas. How greener urban environments may negatively affect health, has been much less studied. This is particularly true in the context of deurbanization/counterurbanization. Cities grow but also evolve in ways that affect, positively or negatively, human and animal health. Urbanization, global trade and travel, and climate change can drive pathogen circulation, and underline the many forms human-wildlife interfaces can take, including in densely built and populated landscapes. Vanwambeke et al. (2019) conclude that firstly, the multifactorial determinants of the complex ecological systems of infectious diseases should be better acknowledged.

In Belgium, regarding tick-borne disease risk in urban areas such as Antwerp, Heylen et al. (2019) underline the important role of green space characteristics as well as measures of connectivity to known source areas. Furthermore, De Keukeleire et al. (2017) show that attention for specific population groups is required: higher exposure is noticed for professionals at risk for tick bites and thus tick-borne diseases, such as veterinarians, farmers, hunters, and gamekeepers. They also call for more education on the risk factors for tick bites and preventive measures for both professionals exposed and the general population. Goeminne et al. (2015) illustrate how in Belgium not only green space but also blue space should be taken into account regarding infectious disease risk: acquisition of *Pseudomonas aeruginosa* in cystic fibrosis patients was significantly higher among patients living nearer to blue space (defined as visible areas of surface water, including but not limited to rivers, lakes, ponds, streams, and brooks). The negative effect found by Aerts et al. (2020a) of high relative cover of grass on child respiratory health could relate to allergic but also non-allergic mechanisms associated to fungi. Potential allergic and non-allergic mechanisms that underlie this association include elevated exposure to grass pollen and fungi, and reduced exposure to environmental biodiversity. Reducing the dominance of grass in public and private green space might be beneficial to reduce the childhood asthma burden and may simultaneously improve the ecological value of urban green space.

Primary healthcare

Primary healthcare is a vital backbone for linking knowledge and practice within the organization of healthcare. A recent review (Lauwers et al., 2020) focused on how nature's contributions to human health are addressed in primary healthcare, including most of the review reports included in this advisory report. Nature related care can be seen as an umbrella term for healthcare interventions related to nature, such as green prescriptions, nature related health interventions, nature-assisted therapies, and green care. Green prescription is a physical activity scripting scheme (written and verbal) whereby patients are initially screened for physical inactivity and receive a physical activity prescription from their general practitioner. A nature related health intervention is a program, activity or strategy that aims to engage people in nature related experiences (and exposure to nature) with

the specific goal of achieving improved health and well-being. Nature-assisted therapy is an intervention with the aim to treat, hasten recovery, and/or rehabilitate patients with a disease or a condition of ill health, with the fundamental principle that the therapy involves plants, natural materials, and/or outdoor environment, without any therapeutic involvement of extra human mammals or other living creatures. Green care is yet another umbrella term for denoting interventions that use elements of nature and defined as a targeted therapeutic or treatment intervention. It is specifically designed for people with a defined need and is delivered by trained/qualified practitioners. However, this term has very broad implications, also including social rehabilitation or health promotion, and also contains animal-assisted therapy. And finally, complementary medicine or alternative medicine, often including the use of medicinal plants, refers to a broad set of healthcare practices that are not part of a country's own tradition or conventional medicine and are not fully integrated into the dominant healthcare system.

The review (Lauwers et al., 2020) concludes that overall, knowledge on nature's contributions to human health in primary healthcare and the role of primary healthcare regarding the application of that knowledge in healthcare practice remains in its infancy in both science and practice. Despite growing evidence of positive health effects of contact with nature, and despite recognition of the important role of general practitioners in the promotion of nature related care (Van den Berg, 2017; Ten Brink et al., 2016; WHO-CBD, 2015), translation of this knowledge into healthcare practice and research of its effectiveness is not common yet (Lauwers et al., 2020; Frumkin, 2017; Van den Berg, 2017). Yet there are good reasons to give this more attention (Lauwers et al., 2020). Primary healthcare has a comprehensive vision on the potential for health promotion and disease prevention, both on individual and population level. Literature regarding "nature related care" describes the potential of primary healthcare in disease prevention on the individual level through health promoting interventions, e.g. physical activity interventions, nature related care, and complementary therapies. On a population level, this literature emphasizes the potential of primary healthcare professionals to have a broad public health impact as they are considered highly credible resources for health information and are often visited on a regular basis by their patients.

Literature about "nature related care" provides several reasons to explain why the green prescribing practice remains low despite the growing evidence on the health benefits of green space (Lauwers et al., 2020). First of all, this field requires the development of a consistent terminology to support a better collaboration between professionals in the health and nature sector. Besides a need for interprofessional collaboration, a behavioural change is required both from the patient and the primary healthcare professional as the new approaches extend the traditional biomedical model. However, the lack of resources and time in the primary healthcare sector greatly challenges the practical trainings and substantial support from the physician toward the patient required for these behavioural changes to succeed. Finally clearer evidence is needed to convince primary healthcare professionals of adapting new practices, but the type of evidence is different from the current evidence base using methodologies like randomized controlled trials. The type of evidence used to indicate the effects of an intervention is mostly based on subjective measures, like self-reported health status. Randomized controlled trials are less feasible for studying the effects of nature exposure, as nature exposure and experience are very context dependent: ecological validity (Andrade, 2018) therefore is more challenging.

In Belgium, research on nature-related primary healthcare is still in its infancy. The University of Antwerp Chair Care and the Natural Living Environment is one example of recent initiatives that aim to develop relevant and scientifically supported collaborations on nature related care with and within the primary healthcare sector.

1.1.3 Social aspects

Social Cohesion

In NHI, social cohesion has been put forward to play a major role (WHO-CBD, 2015). Engaging in social contacts has been found to be of high importance for overall human health and well-being (WHO-CBD, 2015). Nature can have a positive impact on community building (Ten Brink et al., 2016). Urban green spaces can serve as important platforms for social cohesion through intercultural communication, sharing experiences, building understanding, helping to bring people out of isolation, and serving as a starting point for discussions of community issues among the affected people (Ten Brink et al., 2016; WHO-CBD, 2015), thereby acting as multipliers of social capital "*by creating social networking opportunities and a sense of belonging*" (Ten Brink et al., 2016). Opportunities for positive social experiences in nature can be provided by urban agriculture and horticulture (Ten Brink et al., 2016). Increased social engagement can stimulate activities which are associated with healthier lifestyle, with more physical activity, and healthier dietary practices (WHO-CBD, 2015; Ten Brink et al., 2016). It can enhance mood, self-esteem, and mental health, and it can contribute to increased natural capital (Ten Brink et al., 2016). Still, there is no solid scientific evidence for the association between nature and social cohesion. The relatively few studies show mixed results (Kruize et al., 2019).

Belgian research in the city of Ghent (Van Herzele and de Vries, 2012), comparing two neighbourhoods, found that both neighbourhood 'greenness' and social cohesion (but also neighbourhood safety and maintenance of public spaces and streets) contribute to neighbourhood satisfaction. However, the main significant results concerned happiness rather than self-reported general health. Recently, the importance of social (or neighbourhood) cohesion was recognized as an important element for mental well-being by qualitative research in Brussels (Lauwers et al., 2021). Through walking interviews with local residents, this appeared to be partly attributable to UBGS. A Belgian study of Belgian coastal blue space (Hooyberg et al., 2020) investigated social contacts as a potential benefit, but could not draw conclusions in this respect.

Equity

Health benefits of UBGS are not always equally distributed. High quality (e.g. biodiverse) nature is often less accessible to people from groups which are more vulnerable to human health risks such as the elderly, children, people with low SES, ethnic minority groups, women, and housewives (WHO-CBD, 2015; WHO, 2016; IPBES, 2018; Ten Brink et al., 2016; WHO, 2016). In lower-income areas, nature is likely to be of poorer quality (WHO-CBD, 2015). Lower-income groups may benefit with a relatively bigger health increase from nature contact than do higher-income groups (IPBES, 2018). UBGS may also be beneficial for older people and people with a mental illness (Kruize et al., 2019).

As 'upgrading' of neighbourhoods is often associated with increased green space and (consequently) higher real estate prices (Ten Brink et al., 2016), people with higher SES have more opportunities to move to these neighbourhoods, at the expense of poorer people, who are then forced to move to lower-priced neighbourhoods with less nature (Ten Brink et al., 2016; WHO, 2017). Eco-gentrification describes the resulting increases in human health inequity (IPBES, 2018). However, few but large studies suggest 'equigenic' effects of nature: if planned well, nature can contribute to decreasing inequalities in human health. Between people from different SES, in areas with more nature, significant smaller differences in all-cause mortality and mortality from circulatory diseases (WHO-CBD, 2015; Ten Brink et al., 2016; WHO, 2016; WHO, 2017) and mental well-being (Ten Brink et al., 2016) have been found. Moreover, the presence of attractive, high-quality nature may moderate the human health effects of long-term deprivation (WHO-CBD, 2015).

Little is known about equity effects in urban green space interventions (WHO, 2017). Very few studies actually report details of relevant analyses to determine which population subgroups may stand to benefit or be further disadvantaged by urban green space interventions.

The overarching concept of environmental justice describes the political and administrative processes behind human health and environmental equity, including the factors that generate substantial inequalities (Whitmee et al., 2015). Regular maintenance and safety of nature were suggested to play important roles in equal access to nature. Socio-economic status has also been found to influence human health outcomes via perception: people's perception of the distance to their nearest park might differ from the actual distance, and this disagreement may be stronger amongst people of low SES (WHO, 2016; Ten Brink et al., 2016). The ambition of reducing health inequalities is at the core of primary healthcare (WHO, 1978). Partnering with primary healthcare therefore seems of strategic importance also in relation to nature (Lauwers et al., 2020).

In Belgium, Aerts et al. (2020b) show a direct, positive association between cardiovascular medication sales and socio-economic deprivation, and negative associations to green space. Regarding the relation with green spaces though, regional differences were found: the association between green spaces and cardiovascular medication sales was stronger in the region with relatively low green space cover (Flemish Region) than in the region with high green space cover (Walloon Region). In the highly urbanized Brussels Capital Region no convincing association was found. In all regions, the associations between cardiovascular medication sales and socio-economic deprivation were direct and more prominent. The results suggest that there may be a negative association between cardiovascular medication sales and green spaces.

Education

It has been suggested that urban nature may offer opportunities for environmental education at every stage of life (WHO, 2016). Contact with natural outdoor environments has been shown to benefit cognitive functioning in children (Ten Brink et al., 2016). Moreover, nature experiences in childhood may also influence relationships with natural environments (Ten Brink et al., 2016) and children who are more exposed to and educated in and about nature may be more likely to conserve nature themselves as adults, which can assist in protecting nature for future generations. Schools and other institutionalized settings are suggested to be especially interesting for gardening and physical activity promotion projects (WHO-CBD, 2015). Therefore, it could be beneficial to plan playgrounds in parks and to provide more nature around schools and playgrounds. Knowledge of the human health benefits of nature could contribute to motivate people to visit nature more often. Education and community engagement are part of successful projects integrating nature and human health (Ten Brink et al., 2016).

In Belgium, attention for the effects of nature on children's learning capabilities and health in general is emerging. The Flemish Center of Expertise on Environment and Health recently found that nearby green improves attention capacity of children (Flemish Center of Expertise on Environment and Health, 2020). Bijnens et al. (2020) found that in children living in an urban environment an increment of residential green space was associated with a higher total intelligence quotient and lower externalizing behavioural score on the Achenbach Child Behavior Checklist. This indicates that residential green space may be beneficial for the intellectual and the behavioural development of children living in urban areas.

In Belgium attention for the beneficial health effect of green school playgrounds is developing. Greening playgrounds for children's health has been getting more attention over the past years, among other with governmental support. Nature contact at a young age is believed to contribute to pro-environmental behaviour, especially when the nature that is present at the school is also used in the teaching and learning, and does not serve a purely decorative function (Boeve-de Pauw et al., 2017). The recently started B@SEBALL project focuses on the beneficial children's health effect

of nature contact in several regards, with a key focus on beneficial biodiverse microbial contact (B@SEBALL, in progress).

Regarding nature related health risks, De Keukeleire et al. (2017) advise education on the risk factors for tick bites and preventive measures for both professionals exposed and the general population. Lauwers et al. (2020) advise increased education of NHI for primary healthcare professionals.

1.2 Mechanisms

Several explanatory frameworks have been developed for NHI. Below an overview of some mechanistic hypotheses that have been developed over the past decades is presented. These explanatory frameworks, not mutually exclusive, also illustrate the complexity of NHI. They are presented in support of argumentation for policy and practice orientation.

Biophilia hypothesis

The biophilia hypothesis proposes that humans have an intrinsic affinity to other species and nature because interaction with the natural environment drove the evolution of our species (Wilson, 1984). Under the biophilia hypothesis, people are expected to prefer and select biologically diverse environments and derive mental benefits from contact with green space (Frumkin, 2001; Moore & Marcus, 2008; Grinde & Patil, 2009; Hartig et al., 2014). Biophilia studies are often framed in 'stress recovery theory' (natural environments facilitate the recovery from physiological stress). Two leading theories explaining the restorative potential of natural environments in this field of interest are: Ulrich's Stress Recovery Theory (SRT) (Ulrich, 1983), and Kaplan and Kaplan's Attention Restoration Theory (ART) (Kaplan and Kaplan, 1989). SRT states that natural environments can reduce stress due to the innate inclination of humans towards nature, which is their evolutionary habitat (Bornioli et al., 2018; Ulrich, 1983). According to ART, natural environments can support recovery from mental fatigue in the presence of several restorative properties, including being away (being mentally away from routine or demanding activities), fascination (a necessary but not sufficient condition for restoration: being engaged without attentional effort), compatibility (providing a good fit with one's activities or inclinations), and extent (an environment that is coherent, ordered, and of substantial scope) (Kaplan and Kaplan, 1989; Bornioli et al., 2018). Bratman et al. (2015) reveal a pathway by which nature experience may improve mental well-being. In healthy participants a 90-minute walk in a natural setting decreases both self-reported rumination and neural activity in the subgenual prefrontal cortex, whereas a 90-minute walk in an urban setting has no such effects on self-reported rumination or neural activity.

Biodiversity (old friends) hypothesis

According to the biodiversity hypothesis (Hanski, 2012), contacts between people and microbial biodiversity is important for human health, especially in childhood. Chronic human health conditions associated with an urban lifestyle are on the rise (Dye, 2008). One of the main current challenges in this field of research is unravelling the importance of the specific quality of exposure to nature elements (Frumkin, 2017) and biodiversity (Aerts et al., 2018). Enhanced immune functioning emerges as one promising candidate of a central pathway between nature and human health (Kuo, 2015).

Plants, animals and humans are colonized by microorganisms (microbiota) and exposed to countless others (Flandroy, 2018). The microbiota affect the development and function of essentially all organ systems and protects against pathogenic microorganisms and toxins. Genetics and lifestyle factors, including contact with the natural environment, affect the composition of the microbiota, which influences host human health. Humans, animals, and plants share similar relationships with microbes. Research demonstrates the influence of environmental microbial

ecosystems on the microbiota and human health of organisms, and indicate links between environmental and internal microbial diversity and good human health.

Flandroy et al. (2018) further state that human health benefits from residential proximity to the natural environment are also attributable to contact with microbial biodiversity from the natural environment (reviewed in Rook, 2013). Living in proximity to the natural environment affects the composition of the skin microbiota (Hanski et al., 2012; Ruokolainen et al., 2015; Ruokolainen et al., 2017a; Ruokolainen et al., 2017b), and increases contact with microbial biodiversity via the airways (Moore, 2015; Rook, 2013; Schuijs et al., 2015). There are no complete and conclusive studies yet comparing the gut microbiota of people living close and far away from green areas in big cities but work is in progress (Mhuireach, 2016). Based on experimental research with mice, Liidicoat et al. (2020) found evidence that supports the hypothesis that biodiverse soils may represent an important supplementary source of butyrate-producing bacteria capable of resupplying the mammalian gut microbiome, with potential for gut health and mental health benefits. The butyrate-producing bacteria may be capable of resupplying the mammalian gut microbiome, with potential for gut health and mental health benefits in humans.

Dilution hypothesis

The dilution effect hypothesis proposes that high vertebrate species richness reduces the risk of infectious diseases of humans because pathogens are 'diluted' among a high number of animal reservoir species that differ in their capacity to infect invertebrate vector species (Schmidt and Ostfeld, 2001). Under the dilution effect hypothesis, transmission and burden of infectious diseases are expected to be lower in animal species-rich natural environments through lower infection prevalence in vectors (Ogden & Tsao, 2009; Bouchard, 2013; Laporta, 2013; Civitello, 2015; Johnson, 2015; Ostfeld and Keesing, 2017), even when higher species richness also implies higher pathogen richness (Dunn, 2010). However, factors such as species composition, persistence of contacts between reservoirs and vectors, and the various ways in which reservoirs and non-reservoirs are affected by environmental change may all affect the dilution mechanism. The amplification effect (infection prevalence in vectors increases following an environmental change affecting biodiversity) has also been observed (Faust, 2016). The conditions in which dilution or amplification are observed, are still the object of research (Kilpatrick, 2016; Johson, 2015).

Ecosystem services

The benefits that natural and man-made green spaces provide in terms of human health can be classified as ecosystem services (McMichael, 2005; Naeem, 2009; Coutts and Hahn, 2015; Jennings, 2016). Ecosystem services are *"the ecological characteristics, functions, or processes that directly or indirectly contribute to human well-being, i.e. the benefits people derive from functioning ecosystems*" (Costanza, 2017). Environments provide food, fuel, fresh water, medicines, and other materials (provisioning services); regulate local and global climate, air quality, pollination, pests, and vector-borne diseases (regulating services); provide habitat for biological diversity, and maintain genetic diversity (supporting services); and offer space for spiritual, recreational, and intellectual interaction with natural environments (cultural services) (TEEB, 2017). A growing body of evidence shows that many observed associations between contact with green environments and human health and well-being benefits are mediated by a number of crucial ecosystem services (Oosterbroek, 2016). These include cultural ecosystem services that have an impact on stress, and regulating ecosystem services that reduce harmful environmental exposure such as air pollution, extreme heat, urban heat, and noise (James, 2015; van den Bosch & Nieuwenhuijsen, 2017; Shen & Lung, 2017; Markevych, 2017). It should be noted that in the conceptual and operational development of the concept of ecosystem services human health is often 'only' considered to be a subsection of cultural services (Brice, 2016; Bullock, 2018) or even absent (Cheng, 2019). The concept of ecosystem services emerged in the realm of biological sciences with the ambition of exemplifying societal relevance with at first mainly a focus on economic valuation, not incorporating health very explicitly (Ring, 2010).

2. End user needs

Here we present synthesized outcomes of consultations with representatives of end-user groups, in particular in the spatial planning and primary healthcare sectors.

2.1 Spatial planning: policy and practice

Spatial planning and urban development have a major impact on human health. Function, use, and spatial design of the daily life environment determine to a great extent the way and frequency people are affected by harmful environmental exposure, have access to UGBS, or may have contact with nature and biodiversity. Although not always explicitly and in the sense as it is understood today, human health has for quite some time been a further argument to adapt the urban fabric and to develop cities and the urban fringe in order to meet reasonable living conditions for the city dwellers. Installing sanitary sewage infrastructure, building arcades, or zoning different functions, are known in this respect. Avoiding, limiting, or to some extent mitigating the negative impact of activities and environment on living conditions, were and are up until today the objectives. Promoting/fostering a healthy living environment through targeted urban development as a significant objective in its own right, was and is far less a common practice. The former garden cities and green belt towns are to a certain extent examples of this approach. However, recent COVID-19 pandemic events and gained insights relating to predictable impacts of climate change and increasing urbanization, have raised general awareness considerably that there is an urgent need for an urban living environment that sustains and increases human health. Having access to ample green and blue space is key in this respect.

Discussions with spatial planners and designers made clear that human healthcare on the one hand and spatial planning and urban development on the other have been and still are separated domains of policy and practice. Each relies on its own administrative organization, professional associations, legislation, regulations, instruments, and procedures. In practice, human health experts and spatial planners seldom seem to collaborate to achieve the goals they have in common: maintaining and improving human health in an environment that optimizes for this. The ad hoc working group noticed however that spatial planners and designers become aware of the positive role they can play by explicitly including human health in the objectives of spatial development projects. There is a clear willingness to adopt public health goals as can be noticed from the references to human health that are made in several spatial planning policy documents. At the same time, the lack of clear guidelines and proper instruments to contribute effectively to this highly desirable spatial transformation was often mentioned as a major obstacle. Some prospective studies regarding spatial planning tools and human health are drawn up and professional planners start to design spatial development plans from a more integrative perspective, including human health concerns. The latter is mainly achieved by taking existing nature and ecological conditions of an area as the starting point for the location of desired developments and by foreseeing room for new natural elements in public space. Plants and animals that occur and develop spontaneously, together with targeted managed green areas, are thus seen as integral parts of a healthy living environment. ‘Nature-inclusive urban design and architecture’ and ‘animal-aided design’ are getting more attention. ‘Nature related solutions’ are promoted as full-fledged and preferred alternatives for the more traditional technical approach to respond to societal demands.

Spatial planners and designers have a number of demands and proposals in order to integrate human healthcare and urban development practices more efficiently and effectively.

First, there is an urgent need to establish an effective collaboration between the policy domains of public health, spatial planning, urban development, and environmental policy. A coherent framework that enables coordination and integration of instruments and procedures of these domains should be developed. To put shared objectives into practice, new methods and specific instruments such as human health impact assessment have to be implemented. To this end,

current procedures of spatial planning and urban development should also be adapted to take full account of nature and public health concerns.

Second, to make spatial planning and urban development more appropriate to meet the societal demands regarding human health, nature, and the living environment, the administrative organization and division of responsibilities between the different policy levels in Belgium (federal, regional, municipal) should be re-examined. Including nature in development plans to foster public health, calls for an increase of the capacity of competent administrations that have to evaluate, support or realize projects. Quite often, limited resources and staff, a lack of suitable regulations and data, and targeted background information, hinder the efficient and proper handling of complex projects.

Third, although spatial planning professionals are generally aware of the importance to increase and strengthen UGBS and although committed spatial designers and planning organizations started to compile and discuss lists of best practices, the demand for practical guidelines for nature-inclusive development remains high. These guidelines should not only present specific design principles and a toolbox of measures, but should also elaborate on methodologies to analyse the local context and the conditions required to assure a proper ecological functioning of the UGBS.

Fourth, there is a lot of interest in standards and indicators that can be applied to assess the quality of projects regarding functional UGBS inclusion, or to guide spatial design processes which opt for optimizing the benefits of nature and green space for human health. Standards and criteria are straightforward, easy to apply and may serve as the big stick. However, their strict application may cause their local context becomes neglected, that only standard solutions are considered, and hence that innovative or tailor-made designs have no chance to be developed. So, apart from standards, practitioners also want new methods, other than rigid rules and regulations, to realize local high-quality spatial development projects.

Fifth, linking public health, nature and environment, and urban and spatial development into one comprehensive and integrative approach, calls for a change of mind set. Giving room to nature in urban development projects should not be perceived as just another alternative to support human health. An inter- and transdisciplinary approach that acknowledges the complexity of NHI should be promoted. A systemic approach which unifies and concentrates on the interaction between elements, rather than isolating the individual elements, is the logic way to learn about the dynamics and behaviour of the system in order to modify or design it purposefully.

It is generally recognized that for a successful integration, practitioners of the domains of public health, nature and environmental policy, and spatial and urban development should be better informed about each other's activities, methodologies, and strategies. A regular exchange of information and knowledge is highly recommended. Spatial planners and designers should involve nature and human healthcare specialists in an early stage of the planning and design processes so that human health issues get the attention they deserve and can be translated into effective measures.

2.2 Primary healthcare: policy and practice

Overall, knowledge on nature's contributions to health in primary healthcare and the role for primary healthcare regarding the application of that knowledge in healthcare practice remains in its infancy in both science and practice (Frumkin, 2017; Lauwers et al., 2020). Research priority should be given to real-time examples of practice with the assessment of the process and time- and cost-effectiveness to identify best practices. Translation of research into practice should be encouraged, in an evidence based care perspective: ongoing investigations should not impede innovative research regarding (potentially) promising strategies, such as nature related interventions.

The importance of primary healthcare professionals for nature related care and nature inclusive spatial design, is increasing. Lauwers et al. (2020) give several recommendations for better uptake of nature related healthcare. The integration of nature's contributions to health and primary healthcare should preferably be done in a bottom-up manner and horizontal networks among primary healthcare practices and community-based facilities should be stimulated. For example, giving advice only to increase physical activity through green prescriptions is probably not as effective as tailored interventions involving a personalized action plan supported by a strong network between primary healthcare and sport or social services in the community. Such a network builds the opportunity to share the load of intervention activities, as primary healthcare professionals are limited by consultation time. These communal facilities can help in motivating and monitoring the patients in the performance of their physical activities or in providing opportunities for health promotion in general, e.g. the provision of community vegetable gardens or health education activities. Furthermore, regarding infectious diseases, community participation has proven to be a successful element in disease control (Lauwers et al., 2020).

Development of specific tools to support primary healthcare practices are recommended. Primary healthcare practice supporting tools and guidelines are still limited and need to be tailored to be more context-specific. Not only increased attention to the patient's history and background, but also to the context of the primary healthcare professional and of the health issue itself, need further attention. At present, the limited number of tools and guidelines available might be associated with the under-recognition of evidence on nature's contributions to health by health professionals. Tools and guidelines to support the integration of nature's contributions to health and primary healthcare need to be developed. Here we could look at the current practice to develop guidelines for practitioners. In developing guidelines, evidence is collected and given a ranking of its strength (Gopalakrishna et al., 2013).

The growing interest for green prescriptions opens research opportunities to perform prospective studies of the value of nature on health in the primary healthcare setting. Further investigation of the added value of a natural environment for physical activities and how the patient can be stimulated through a community-based referral network to visit natural environments for physical activities is recommendable.

Regarding infectious diseases the importance of a One Health approach should be emphasized: the necessity to further investigate ways to strengthen the collaboration between environmental, human, and animal healthcare sectors for disease control and prevention, with primary healthcare being an ideal setting to converge those disciplines. Primary healthcare can report back to research, and as such deliver important data to science. Further, the importance of reducing health inequalities in communities is very much at the core of primary healthcare ambitions: primary healthcare can therefore also play a role regarding nature related equity-effects.

The importance of close collaboration between the healthcare and spatial design sector is seconded by healthcare professionals as crucial, but also as challenging: such integrated and collaborative effort is still in its early development stages. In addition, the importance of application of health impact assessment approaches in the realm of spatial planning is recommended, e.g. by integration in environmental impact assessments.

Regarding nature related care, the need for professional standards is highlighted. A prominent example is the emerging practice of nature related health coaching, which is currently not regulated, nor sufficiently founded on evidence based medicine/practice, nor supported according to professional healthcare standards. Furthermore, embedding these practices in broader care networks like highlighted above, could enhance not only the practice application of nature related care opportunities (e.g. as social prescription), but also support the critical professional reflexivity of these practices, by professional connections with recognized healthcare professionals such as in primary healthcare.

IV. CONCLUSIONS AND RECOMMENDATIONS

1. From science to policy to better health

Conceptually the health of an individual is the result of their genetic traits and the way one is exposed to and able to cope with external influences (Barton and Grant, 2006; WHO-CBD, 2015; Lindey et al., 2019; Marselle et al., 2021). However, the simplicity of this concept is deceptive. Not only do these genetic traits change in the course of life by aging processes and by the interaction with external determinants. Moreover, these external determinants are in themselves a complex interplay of biophysical factors, the availability of food and water, and economic, social and cultural norms and pressures, and learning processes (*ibid.*). More and more there is an awareness that human health – individually and collectively – depends on the functioning of processes in social-ecological systems. The One Health concept (chapter I.2 of this report) takes this system view on health one step further by integrating human, animal, plant, and ecosystem health.

Nature-health interlinkages in urban settings, the focus of the present report, operate within these social-ecological systems. Given the complexity of urban areas – i.e. urban social-ecological systems – as indicated above, despite rapid increase in the numbers and diversity of relevant scientific studies, it will not come as a surprise that the scientific knowledge about these interlinkages remains hampered with uncertainties and unknowns. Further research will resolve some of these knowledge gaps, but the Council stipulates that the inherent complexity of urban areas, also in terms of their development in the course of time, results in inherent uncertainties and unknowns.

Notwithstanding this, the Council concludes from the available data that there is ample room for improvement of health by taking account of the nature-health interlinkages, in parallel to ongoing development of scientific understanding. This improvement increases the health benefits and reduces the negative health impacts not only of humans in urban areas but also of other species and urban ecosystems. Therefore, the Council proposes to use the available knowledge in local, national and international governance to further health. The notion of ‘governance’ is used, as it is a broader concept than that of (government) policies.

In particular in the present century, natural and social scientists have increased efforts to understand the way social-ecological systems behave, develop, and change (Chaffin, 2016; IPBES, 2019; Bulkeley, 2020). Systems develop by internal processes, but also due to global and more local processes and pressures. Examples of global processes and pressures on urban areas are climate change and biodiversity loss. More local processes are individual demands for private car use. Which governance approaches can counteract pressure and optimize the urban area health? One way is ‘adaptation’. Urban areas can adapt to pressures from global developments. For example, heat protocols have been developed to adapt as far as possible to heat waves associated with climate change and prevent premature deaths. Cycling paths and pedestrian walkways in inner cities counteract excessive private car use and a growing number of cities are using vegetation to reduce the urban heat island effect, or to increase the attractivity of walking and cycling, and to promote active mobility.

However, the Council believes that in many urban areas more fundamental changes are required, leading to forms of ‘transformative’ governance. Unfortunately, there is no standard recipe for transforming urban areas in order to further health in its broadest sense. As discussed in the present report ‘greening and blueing’ the area might play a key role, but in which way depends on the specific situation of an area: each urban area has its own, specific natural, social, cultural, and economic characteristics. Further below the Council will present more specific recommendations that should be considered in developing policies for transformative governance.

However, transformative governance and policies to effectuate transformation of an urban area need not and, in the opinion of the SHC should not be thought of as rebuilding the urban social-

ecological system from scratch. Series of adaptive measures, as illustrated above, might be used as a stepwise approach to transformation of the urban area. A stepwise approach also might avoid gross failures in improving the health of the urban systems and its constituents. Given the inherent uncertainties about the way an urban system may react to policy measures, it is difficult to predict whether a measure or set of measures are effective. Lessons learned from one urban area can be helpful in transforming another one, but it is unlikely that both areas will react in the same way.

So following a stepwise, adaptive policy for transforming the urban area into one with better prospects for human, animal, plant, and ecosystem health is recommended. But how do we know whether the transformation is succeeding? Given the inherent complexity of social-ecological systems, such as urban areas, assessing the result of policy measures and the actions taken by governments, private organizations and citizen groups is seldom unambiguous, also because different groups may have different preferences or stakes, which warrants an inclusive deliberative approach. Health in itself is an unmeasurable concept, so indicators are necessary (Briggs, 2008). With respect to human health the Council advises to take account of the European URHIS project, which studied the application of urban health indicators in Europe (Pennington, 2017; Gemmell, 2017; Patterson, 2017). In particular aggregate indicators can be helpful to reduce the overwhelming complexity in assessing the result of policies and subsequent actions. But in this 'search' for the effect of nature related interventions to foster urban health the Council strongly advises to take a step-by-step approach, and thoroughly monitor results using an appropriate set of indicators through a continuous process of health policy impact assessment (Briggs, 2008). A prudent, step-by-step approach not only avoids following irreversible, ineffective pathways but also serves as a feedback to science for enhanced understanding, and incorporation of new insight regarding unforeseen complexities.

2. Recommendations

The following key recommendations were developed by building on IPBES (2018) and consultation of Belgian experts.

Mainstream interlinkages between UGBS and human health through all levels of society.

- Include nature visits in, amongst others, (pre)school routine and work routine.
- Elaborate on communication frameworks for the interdisciplinary education of the public and for raising awareness and engagement for UGBS by the public.
- Include collaborative planning, maintenance, and management of UGBS into city development programmes.
- Also focus on inter-sectoral collaboration, especially between human healthcare and spatial planning, and participatory processes, involving diverse societal groups.

Expand and strengthen transdisciplinary and multisectoral frameworks such as One Health and EcoHealth.

- Foster knowledge exchange between and beyond plural research disciplines, institutions (environmental, (primary) human health and others), and policy levels.
- Next to multisectoral collaboration, these frameworks can simultaneously reinforce the science-policy-society interface and the interaction with the legal and the non-profit sector.
- Support the work of the Belgian One Health network (BEOH) for that purpose.

Co-integrate biodiversity and human health into all levels of governance.

- Extend transdisciplinary policy platforms combining nature and human health and well-being that are well connected with science and other institutions.
- Combine human health and biodiversity in strategies, programmes, projects and plans.

- Develop no-regret policies: given a degree of scientific uncertainty about future scenarios, no-regret policies are those that are worth doing now regardless of which scenario actually plays out.

Foster the transparency, monitoring and implementation of current knowledge.

- Evaluate past and present research on NHI to illuminate their scope and diversity and the ways through which they have been investigated.
- Encourage disclosure of non-significant research results or methods, which may be informative to generating further knowledge development.
- Create a more integrated research program in which qualitative and quantitative research can be combined.

Develop more resilient and effective human health systems that integrate human health and environmental care.

- Complement existing, curative approaches to primary healthcare with a focus on integrative approaches applying preventive human health aspects of UGBS.
- Monitor these interventions from a research perspective.

Foster human health equity.

- Develop and implement participatory strategies which ensure design and management of urban and peri-urban nature projects
    - that maximize the accessibility and human health benefits of urban and peri-urban green and blue space for vulnerable groups,
    - that avoid eco-gentrification,
    - and enhance sharing of UGBS.

Include the human health effects of UGBS into spatial planning and urban development plans, while taking into account local needs and also inform citizens about biological risks involved in nature contact.

Support longitudinal, transdisciplinary research projects in which both human health benefits and risks of UGBS are investigated in an integrated way.

- Proposed topics include:
    - the preventive aspects of UGBS for the development of mental illnesses, human health and equity effects of blue spaces;
    - other mechanisms through which UGBS affect human health including social cohesion;
    - the effects of UGBS on light pollution, dementia and obesity.
- Specific research challenges are:
    - developing tools for UGBS human health impact assessment;
    - developing integrated research models;
    - longitude studies for long term human health effects.

Support detailed research on the linkage between the human immune system and the natural environment.

- Further epidemiological studies should explore
    - the importance of the microbiome in NHI, including the interaction with other factors such as nutritional status;
    - whether there is a “critical period” (e.g. season) for such contacts;

- the preventive effect of UGBS against the development of allergies, asthma, mental health problems;
- the influence of individual factors such as socio-economic status, gender, migration background.

Promote practice-oriented research.

- Monitor applications and outcomes of therapies that include different types of nature visits in order to develop guidelines and guidance for human health workers on how to use natural environments for human health promotion. Additionally further research is needed on mechanisms mediating human health effects. Also monitoring and evaluation in a broader sense (not only therapies) is needed.
- Develop research on human health equity aspects of UGBS, both quantitative and qualitative.
- Improve the integration of healthy and accessible urban and peri-urban nature: develop and promote the use of single, unified tools for measuring, implementing, analysing, mapping, and monitoring the availability, access, elements and human health effects of current and future UGBS projects. Examples that can contribute to the evidence base include human health impact assessments, e.g. to be included in existing environmental impact assessment instruments.
- Develop a knowledge base which allows to identify which and what amount of biodiversity is needed to support human health and further investigate/clarify underlying mechanisms.

Invest in collaborative research.

- Focus on social engagement, e.g. through citizen involvement such as in citizen science.
- Develop interdisciplinary research projects to develop methodological and communication support for intersectoral collaboration.
- Create a more integrated research program in which qualitative and quantitative research can be combined.

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VII. COMPOSITION OF THE WORKING GROUP

The composition of the Committee and that of the Board as well as the list of experts appointed by Royal Decree are available on the following website: About us.

All experts joined the working group ***in a private capacity***. Their general declarations of interests as well as those of the members of the Committee and the Board can be viewed on the SHC website (site: conflicts of interest).

The following experts were involved in drawing up and endorsing this advisory report. The working group was chaired by **Hans KEUNE** and **Wim PASSCHIER,** the vice chair was **Sophie VANWAMBEKE**. The scientific secretary was Marleen VAN DEN BRANDE.

AERTS Raf	Health impact assessment	Sciensano
DE BLUST Geert	Spatial planning, biodiversity	UA/INBO
FALLON Catherine	Social sciences	ULg
KEUNE Hans	Ecosystem services, ecohealth, onehealth	BBPF//INBO/UA
LOOTS Ilse	Social sciences	UA
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VAN DIJCK Hans	Biodiversity	UCL
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The standing working group on chemical agents has endorsed the advisory report. The standing working group was chaired by **Luc HENS**. The scientific secretary was Marleen VAN DEN BRANDE.

BOULAND Catherine	Environmental and occupational health	ULB
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HOLSBEEK Ludo	Ecotoxicology	LNE
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SMAGGHE Guy	Ecotoxicology	UGent
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The following expert was heard but did not take part in endorsing the advisory report:

AVONTS Dirk	Health practice	UGent

The following administrations and/or ministerial cabinets were heard:

BIOT Pierre	DGEM – Multilateral and strategic affairs	FPS Health, Food Chain Safety and Environment
DEHON Vincent	DGEM - Product policy and chemicals, MRB Biocides	FPS Health, Food Chain Safety and Environment
DEHOUX Fabrice		Federal Council for Sustainable Development
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The following experts peer reviewed the advisory report but did not take part in endorsing it:

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PASCAL Mathilde	Health and environment, epidemiology	Agence nationale de santé publique - France

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