Reintroduction of health impact assessment in Bulgarian city planning – why and how?

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Abstract
Bulgaria has established practices in Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA), yet the integration of applied. Health Impact Assessment (HIA) research findings in the practice of urban planning, governance, and development is limited or absent. This study highlights the pressing need for reintroduction of HIA in the Bulgarian spatial planning system and proposes how that can be accomplished without excessive regulatory burden to city authorities, planning and design experts, (re)developers, and citizens. Drawing on local Bulgarian and international research experience with HIA-based urban planning, the present study conducts a comparative analysis of HIA regulations, provides an overview of health related SEA content, recent exposure studies for the 5 biggest cities in Bulgaria, and ultimately attempts to conceptually reframe HIA in the urban development practice.

Keywords: city planning; urban environment; health impact assessment; exposures; decision framework

Introduction

Urban environments shape human health through a range of direct and indirect pathways involving exposure to stressors, behavior modification, and salutogenic influences building resilience (Mueller et al., 2021). Compact and densely populated cities often amplify exposure to air pollutants, noise, artificial light at night, heat islands in summer seasons, and result in limited availability or inaccessible green space, exacerbating both physical and mental health disorders (Dyer et al., 2024). The means of production and consumption, shaped by political-economic systems of governance and spatial development configurations, influence air quality, the acoustics environment, energy dynamics, viewsheds, food availability, mobility modes, and physical activity among other characteristics of the living environment affecting health and quality of life (Barton & Grant, 2006; EEA, 2010; Krefis et al., 2018; Mouratidis, 2021). Historical waves of deindustrialization have left a legacy of unequal spatial development, often concentrating health risks in socioeconomically disadvantaged areas (Hajat, Hsia & O'Neil, 2015). Mixed use services oriented redevelopment and reindustrialization offer various opportunities for urban regeneration while technological and organisational advancements such as the smart city and circular economy concepts may optimize and prevent excessive energy and resource use. Nevertheless, all of these good intentions in cities' development may provoke new pressures and add specific adverse cumulative effects due to unbalanced patterns of spatial development relations and rebound effects (Parrique et al., 2019; Castro et al., 2022). The structural health-determining patterns and the future opportunities call for integrated public health-oriented urban design strategies that not only mitigate risks but also foster equity and resilience in the endless quest for sustainable cities.

Urbanization in Bulgaria is shaped by a post-socialist legacy, characterized by uneven development, deteriorating infrastructure, and persistent environmental issues. Many urban areas still bear the imprint of industrial pollution (e.g. Varnagglomeration, Burgas, Pernik) or newly emerging consumption externalities, especially in cities like Sofia and Plovdiv, where PM10 and PM2.5 levels regularly exceed the World Health Organization air quality guideline limits standards (European Environment Agency, 2023), while NO2 levels are often not in the spotlight that stay hidden from the official monitoring systems although there is confident evidence that it is an important issue (Popov & Hlebarov, 2021). This contributes to non-communicable disease respiratory and cardiovascular morbidity and mortality, disproportionately affecting mostly children and the elderly (Health Effects Institute, 2024). Despite its membership in the European Union and its current application for OECD accession, Bulgaria has recorded the highest mortality rate in the EU, with a crude death rate of 15.7-22.9 deaths per 1,000 inhabitants between 2019-2023 compared to the EU average of 10.4-11.9 (Eurostat, 2025). This reflects the combined impact of demographic shrinkage, population aging, chronic disease prevalence, underfunded health systems, and socioeconomic stress.

Health Impact Assessment (HIA) has emerged as a key tool for making health a visible and accountable component of urban planning and the parallel ex-ante and ex-post evaluation instruments (Mueller et al., 2021, 2023). The WHO's Healthy Cities movement provides a flagship guidance on the overall policy and tools, promoting governance

models that embed health into municipal decision-making via a series of indicators, such as health, health services, environment and socio-economic conditions oriented ones (Webster & Sanderson, 2012). HIA complements other legislatively established evaluation tools such as Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA), offering more detailed insight into local health status and projected outcomes. While SEA and EIA focus generally on environmental and ecological impacts, HIA places explicit emphasis on population health, wellbeing, and social equity and thus is helpful in bridging societal and environmental aspects with people in the focus. Incorporating high quality HIA into these broader environmental assessment frameworks at the strategic planning and the project level ensures that health benefits are not seen as a byproduct but a central consideration in the different scales of urban development policy and decision making.

Integrating HIA helps identify co-benefits and trade-offs early on in planning processes and drive and orient, inform or strongly support planning and decision-making approaches, alternatives and choices. The gradually improving local evidence and global understanding of health - urban environment relations make HIAs more relevant and with higher resolution thus increasingly helpful for the targeted design of urban level solutions.
The present study addresses two main points:

1) The pressing need for reintroduction of more advanced and robust HIA in the Bulgarian spatial planning system.
2) The feasible implementation of HIA without an excessive regulatory burden to city authorities, planning and design experts, (re)developers and citizens.

Materials and methods
Drawing on experience from one pilot (UBSP, 2025) and three research projects (CES, 2025; SU, 2025; MUP, 2025) as well as other related actual studies carried out by the authors, conducted in major Bulgarian cities, this paper proposes a framework for reintroducing and improving the quality of evidence-based HIA in the country. The study offers insights by drawing on three qualitative analysis approaches:

1. A comparative analysis of international regulations and the current state of HIA practices at the urban level in Bulgaria as well as stakeholder analysis and survey;
2. An overview of urban environment - public health interactions and exposure patterns across Bulgaria's five largest cities, with a particular focus on Sofia, highlighting some of the key urban exposures such as air, noise, and light pollution, alongside the characteristics of green spaces and their accessibility;
3. A conceptual reframing of approaches to address urban environmental pressures and develop balanced strategies for creating healthier urban environments in Bulgaria in the near future.

We first review existing international standards, EU regulations, and nationally adopted legislation regarding monitoring, screening, mapping, programming, and action planning in the urban environmental domain. The comparative analysis of international regulations and the current state of HIA practices at the urban level in Bulgaria covers WHO and selected national recommendations and their application, the EU acquis transposition in relations to SEA and EIA. Next a brief overview of the variety of procedural and content oriented norms in selected countries and the differences in capacity, that is scientific, professional, and political will for evidence-based decision making is presented as well as an overview of Bulgarian regulations and analyses of the SEA-related content of the general spatial development plans of the cities of Sofia, Plovdiv, Varna, Burgas and Ruse. As part of one of the studies on joint effects on urban health, a purposive sample of stakeholders using the Delphi method is compiled and surveyed. The initial iterative discussion process went through several stages of defining specific aspects of social or natural phenomena in the urban environment - health nexus, identifying individuals, groups or organizations affected and/or that may have an impact on the urban planning and management decisions and thus prioritizing participants to be invited. The output of the stakeholder analysis is represented as initial findings.

We then present an overview of the urban environment - public health relationship and discuss exposure patterns in Bulgaria's capital and other large cities. In particular, we draw on the projects mentioned above and represented in more depth later in the text with short 'nicknames' as follows:

1) **Urban Standard** or originally "Set an **Urban Standard** - Creation of a Standard for Evaluation and Monitoring of the Quality of the Urban Environment" (UBSP, 2025);
2) **URBiNAT** or originally "**URBiNAT** - Healthy corridors as drivers of social housing neighbourhoods for the co-creation of social, environmental and marketable NBS" (CES, 2025);
3) **Methodology for air and health assessment** or originally "Development of a **methodology for air** quality **and** human **health** risk **assessment** in urban areas";
4) **Joint effects** or originally "**Joint effects** of exposures to natural and built environments – informing healthy and sustainable urban development".

More information about the sets of methods and results are described and compared in 3.2. Additional references are included in terms of important screening studies in this knowledge base review - outlooks and compilations of the Health Effects Institute (2022, 2023), the EXPANSE, UBD Policy Horizon 2020 projects. The latter combines resources with the Methodology for air and health assessment and the Joint effects projects in order to bring the research experiences with Sofia to a higher level (Khomenko, 2025).

The exposures of interest here include air pollution, traffic noise, artificial light at night, greenery and urban health islands. Particular focus is on Sofia, the capital city of Bulgaria.
The conceptual reframing of HIA in Bulgarian urban planning practice is made on the basis of definitions and principles stemming from the outlined gaps and the compact review of the international regulations, national practice and stakeholders' survey, as well as the accumulated research evidence.

Results

3.1. A comparative analysis of regulations of health impact assessment practices at the urban level in the EU

The comparative analysis of regulations regarding HIA is represented by an unfolding matrix of procedural and substantive issues. The comparison includes neighboring countries of Bulgaria (Romania and Greece), countries of similar population size (Denmark, Ireland, Austria), and other influential or role model ones in the urban development domain (The Netherlands, Germany, France, Spain, Italy, Poland). As in most cases in Europe, HIAs are part of the SEA and EIA content, so an overview of the legislative framing of both is shown in Table 1.

Table 1 Types of national legislation transposing the SEA Directive in selected EU countries (based on EC, 2025)

Type of legislation	SEA legislation	Integrated legislation		
Country		Environmental code / protection act	EIA legislation	Sectoral legislation
Austria				Δ(federal level and in some provinces)
Bulgaria	Δ(by-law)	Δ	Δ(by-law)	
Denmark	Δ(SEA and EIA together)			
France		Δ		
Germany	Δ		Δ	Δ
Greece	Δ			
Ireland	Δ			

Italy		Δ		
The Netherlands			Δ	
Poland		Δ	Δ	Δ
Romania	Δ			
Spain	Δ(SEA and EIA together)			

The Environmental Protection Act (EPA) in Bulgaria regulates the obligation to carry out a strategic environmental assessment or as it is called "ecological assessment" of policies, plans and programs, and an environmental impact assessment (EIA) of investment design projects in order to prevent, reduce or compensate for harmful effects of planned activities on nature and human health. The SEA related ordinance (CMRB, 2020) further defines the procedures and criteria for carrying out EAs.

The main focus is on the systematic assessment of likely significant impacts, including the ones on human health.

Table 2 Comparative analysis of regulations of health impact assessment at the urban level in selected countries (EU, 2001; EC, 2019a,b; 2025)

Country and responsible regulative bodies	Key regulatory acts and complimentary documents	Themes - factors and indicators	Evaluation cycle steps and health considerations	Urban planning related requirements
European Union				
European Parliament Court of Justice of the European Union European Environmental Agency	Directives 2001/42/EC (SEA) and Directive 2011/92/EU (amended by 2014/52/EU) (EIA) as well as guidance documents	Biodiversity, population, human health, fauna, flora, soil, water, air, climatic factors, material assets, cultural heritage, landscape and the interrelationship between the factors	Screening, Scoping, Reporting, Consulting, Decision making, Monitoring Para 1, Annexe I (f) and II (2)	Health impacts considered as part of the assessment of significant environmental impacts of plans and programs via SEA and EIA
Bulgaria				

Ministry of Environment and Water Executive Environmental Executive Agency Regional Inspectorate of Environment and Water Regional Health Inspectorate	Environmental Protection Act (EPA), 2002 and later amendments; (SEA) Ordinance on the conditions and procedure for carrying out an environmental assessment of plans and programmes, 2004 and later amendments; (EIA) Ordinance on the conditions and procedures for carrying out environmental impact assessment, 2006	Components: atmospheric air, atmosphere, waters, soil, subsoil, landscape, natural sites, mineral diversity, biological diversity and its elements; Factors: natural and anthropogenic substances and processes; waste; risky energy sources - noise, vibrations, radiation, GMO (Art.4, EPA)	Screening, Scoping, Reporting (assessment of the alternatives through comparison of planning options with), Consulting (a prolonged Aarhus convention case for Bulgaria regarding both the information and environmental justice aspects (UNECE, 2025)), Decision making (elaboration of reasoning and criteria for selection of the best alternative), Monitoring (setting of indicators for post-approval monitoring and control of the implementation)	Urban planning not explicitly addressed, overall implications for spatial planning. The state of health affected by the state of environmental components, or via them by the factors, actions and measures (Art. 19, EPA); The report must assess impacts on health among the other aspects (Art. 86, para. 3, pt. 6, EPA) Considerations of the objectives, territorial scope, level of detail related to investments, location, characteristics, scale, and impacts of plans in general and general spatial development or detailed urban design plans in particular (Art. 81, para. 3 and Art. 85, para. 1&4, EPA; Art. 8a, para. 2 SEA Ordinance)
Other EU countries (Romania, Greece, Italy, Spain, France, Netherlands, Germany, Austria, Danmark, Ireland)				
Various, e.g. ministries (Greece), inspectorate (France), commission (Netherlands)	Single (e.g. Greece, Romania) to many acts, based on sectoral distribution of issues and/or hierarchy of acts (e.g. France), federal divisions of legal responsibilities (Germany, Austria)	Most notably air quality and noise, as well as a number of other themes similar to the ones described in the EU SEA and EIA directives and other specific themes highlighted in the national context	Adherent to the EU directives, including Screening, Scoping, Reporting, Consulting, Decision making, Monitoring Various guiding documents on separate steps of the process (e.g. Poland, Austria, Netherlands)	Additional procedural and content support such as urban planning guidance (e.g. France), GIS environmental sensitivity mapping portals and tools (e.g. Romania, Ireland)

Compared to other countries, Bulgaria has a well-developed legislative base, both SEA and EIA related, although more generic in terms of the HIA specific implications, methodological and technical and in the urban planning and geospatial field. The health protection is included in the EPA as well as in the Health Act, and there is synchronization in procedural terms but content of HIAs is not comprehensively addressed.

Content analysis of SEAs with focus on the HIA related content

Further on an exhaustive review of available health related assessments is presented drawing on the content of Strategic environmental assessments in the 5 biggest cities in Bulgaria.

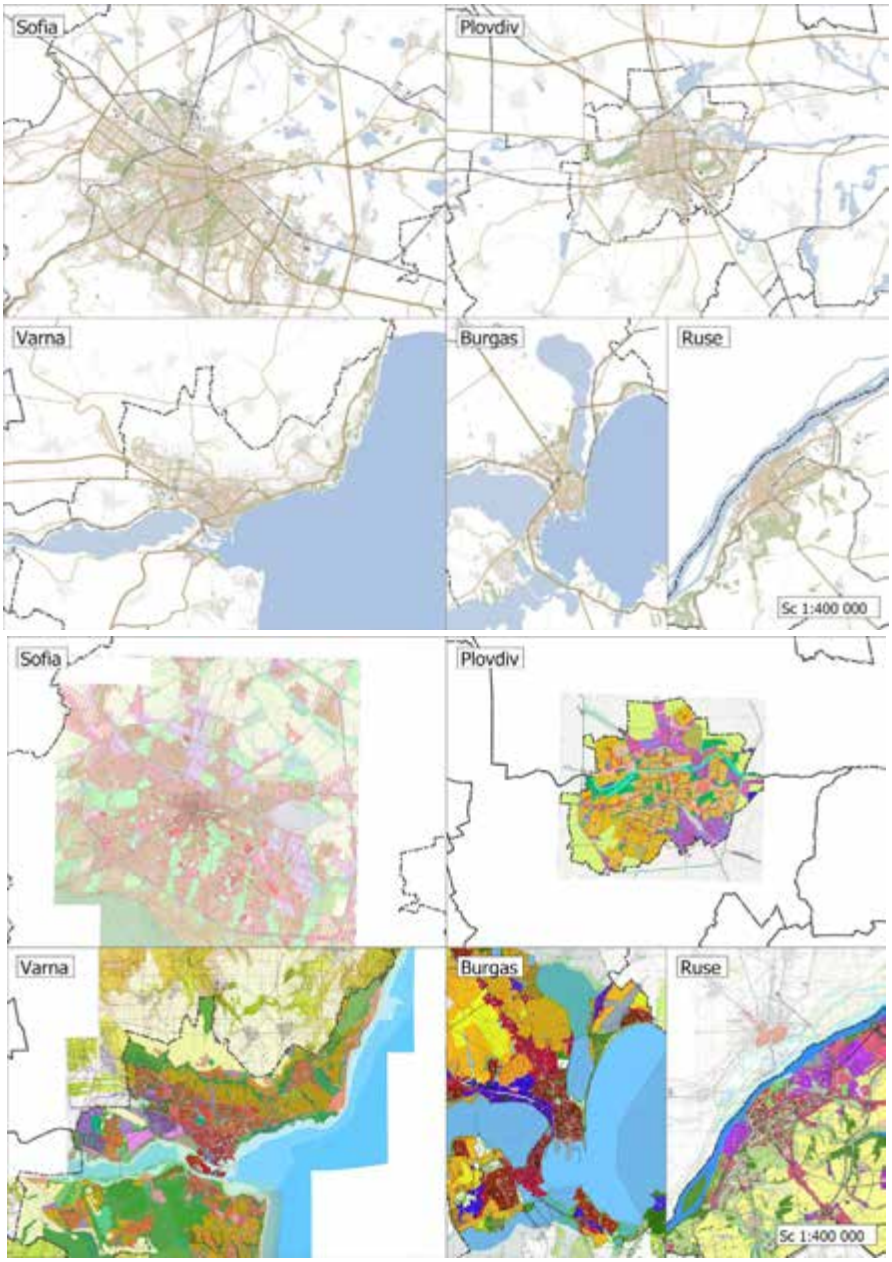

Figure 1 The 5 biggest cities (2023), their basic shape and the actual masterplans

The SEA content reviewed includes the available profiles in the official registry of the Ministry of Environment and Water (MEW). Additional sources like municipal portals are also used where older assessments are available, especially for the case of Sofia, whose spatial development plan and its SEA are preceding the creation of the registry (Sofiaplan, 2025). The selection of cities is based on their population size until 2023 when the last survey, part of the Joint effects project, was implemented.

Table 2 Review of SEA's health related content of the 5 biggest cities until 2023 in Bulgaria (Sofiaplan, 2025; MEW, 2025)

<table>
<tr><td>Health related content - quantity (number of mentions of the health word root) and quality (paragraphs with concentration of the root word)</td><td>Overall evaluation of the HIA aspects in terms of health data, statistics and geospatial data metrics used for impact assessment</td></tr>
<tr><td colspan="2">Sofia (SEA built upon preceding EIA but much lighter in tune with the SEA directive and national legislation) (Sofiaplan, 2025)</td></tr>
<tr><td>Quantity - 1 procedure, 269 mentions in Volume II of the SEA from 2008</td><td>Moderate amount of regional (equal to local level) health data used thanks to the overlapping of the regional district and the metropolitan municipality</td></tr>
<tr><td rowspan="2">Quality - pp. 556-559, 560-567, 573-600
describing conditions and state of health related factors; pp. 615-632 description of expected impacts mostly associated with climate, air quality and noise; 637-641 methodological description for the component and factor analyzes; annexes with prescription of mitigation and abatement measures</td><td>Health statistics are cited and descriptively analysed and projected by expert judgement on the basis of trends analyses and first tier modeling of components and factors</td></tr>
<tr><td>Geospatial data metrics are neither cited, analysed or applied due to lack of available data (though the preceding EIA of the draft version of the plan from 2002 included such a pilot interdisciplinary attempt thanks to intensive field work with district clinics and processing of analogous data)</td></tr>
<tr><td colspan="2">Plovdiv (SEAs) (MEW, 2025)</td></tr>
<tr><td>Quantity - 2 procedures, 41 mentions in the SEA from 2007, no health related SEA content from the amendment in 2020</td><td>Low amount of health data used</td></tr>
<tr><td rowspan="2">Quality - pp. 53-54 describing conditions and state of health related factors; pp. 72-74 prescribing mitigation measures against the expected impacts mostly associated with air quality, noise and water quality</td><td>Health statistics are neither cited nor analysed</td></tr>
<tr><td>No geospatial data metrics cited, analysed or applied</td></tr>
<tr><td colspan="2">Varna (SEA) (MEW, 2025)</td></tr>
<tr><td>Quantity - 1 procedure, 67 mentions in the SEA</td><td>Moderate amount of health data used</td></tr>
</table>

from 2009	
Quality - pp. 31-32 describing conditions and state of health related factors; pp. 60-65 prescribing mitigation measures against the expected impacts; pp. 65-85 prescribing mitigation measures against the expected impacts mostly associated with air quality, noise and water quality (incl. bathing waters)	Health statistics are cited and descriptively analysed
	No geospatial data metrics cited, analysed or applied
Burgas (SEAs) (MEW, 2025)	
Quantity - 6 procedures, 172 mentions in the last SEA from 2022, 84 mentions in the first SEA from 2007, the interim amendments of the plan are not directly related to health issues	Moderate amount of health data used
Quality - 2007 SEA, part 2 pp. 101-103 describing conditions and state of health related factors, part 3 with consistent methodology for multiple environmental issues; 2022 SEA of a partial amendment, pp. 34-40 and 96-100 describing conditions and state of health related factors	Health statistics are cited and analysed, interpretative and data based impact evaluation matrices is used
	Geospatial data metrics cited, analysed or applied through modeling of pollutants (e.g. atmospheric)
Ruse (SEA) (MEW, 2025)	
Quantity - 1 procedure, 150 mentions in the SEA from 2018	Low amount of health data used
	Health statistics are cited and analysed
Quality - distributed paragraphs across the descriptive and prescriptive parts	No geospatial data metrics cited, analysed or applied

The HIA related content is too general, except for Sofia and Burgas cities. Most of the initial plans were elaborated more than 15 years ago and the monitoring of their implementation is missing. Amendments are avoided due to procedural fears and the ones present avoid more thorough HIA, while consultations provide demand and proposals for more emphasis on the health effects.

Juxtaposing the regulative comparison and the content analysis we provide evidence that the health aspects are broadly mentioned in the Bulgarian legislation but the HIA guidance and planning and decision support tools are missing, while the content in the SEAs where such assessment usually has to take place is too vague and outdated. Much more is needed in order to address this pressing issue, given the exposure evidence and the related health risks in the Bulgarian cities and among its vulnerable population.

Stakeholder analysis

A purposive sample of stakeholders was surveyed to collect information on their self-assessments of awareness, interest, influence, knowledge of the major settlements; identification and prioritization of current issues of urban environment associated with health; as well as their opinions on the necessary actions/decisions; barriers and opportunities to overcome those, experience in evidence-based approaches and preferences as well as anticipated future problems and expected benefits for the urban quality of life. The initial consensus sample comprised 354 individuals associated with 136 organizations representing international, national and local institutions, political, governmental, business and non-governmental organizations, academia and professional communities, etc. invited to take part in the on-line survey. Results were obtained from 108 respondents from the 5 major cities in Bulgaria who were well familiar with the urban environment of more than one city – the highest rate being 79% (n=85) for Sofia, 48% (n=52) for Plovdiv, respectively 40% (n=43) for Burgas, 30% (n=32) for Varna and 13% (n=14) for Ruse overall comprising 32% (n=35) governmental/central authorities and national institutions or agencies, NGOs accounted for 19% (21), 16% (n=17) members of academia, researchers and experts, followed by business stakeholders 13% (n=14) and active citizens - 10% (n=11).

Respondents' professional roles are predominantly policy enforcement and planning ones and the scope of expertise is regionally and locally oriented for most of the half (fig. 1). Perceived ability to influence urban health decisions differed significantly and was highest for Sofia - 66% (n=61) while for Plovdiv and for Burgas it was respectively 25% (n=23) and 24% (n=22) and much lower for Varna - 10% (n=9), and Ruse at 8% (n=7), aligning with Sofia's role as a policy and decision-making hub.

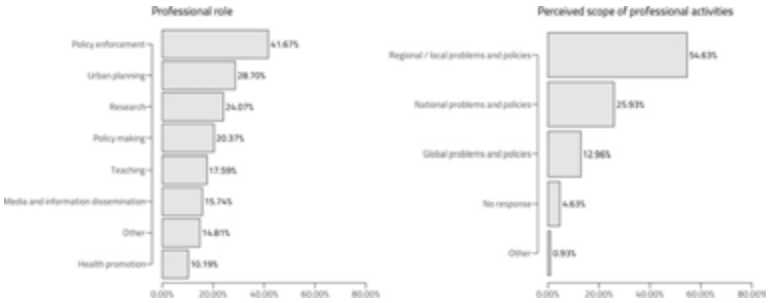

Figure 2 Professional role and activities of respondents

The priority challenges stated by the respondents are led by the urban air pollution, followed by issues related to the capacity and compactness of the city and the quality of green spaces, almost equally prioritized with the noise pollution (fig. 2).

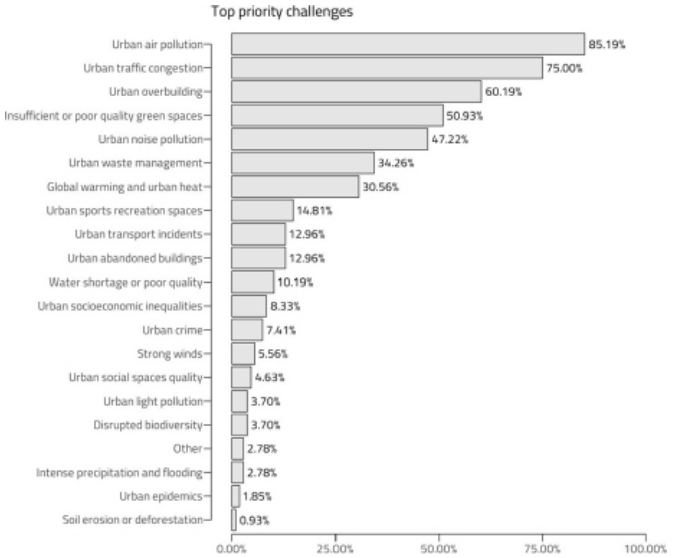

Figure 3 Priority challenges for health in the urban environment

Respondents awareness levels were high with urban environment issues having a profound personal significance for the stakeholders - 57% (n=61) reported being affected "very much" and in 39% (n=42) being "quite affected" and 44% (n=48) claiming expert knowledge of urban planning and evidence-based decision making supporting the idea of a well-informed respondent pool.

Policy preferences for tangible, high-impact interventions aligned closely with identified urban environment issues and policies targeting improvement of urban air quality were endorsed by 74% (n=80), followed by enhancing mobility and transport connectivity in 55% (n=59), improving green spaces quality and/or quantity in 42% (n=45).

Expected direct QoL benefits when effectively addressing urban challenges were mainly health related - improved public health indicators in 78% (n=83) associated with improved air quality, resulting in increased citizen satisfaction (77%, n=82) but also reduced noise levels (51%, n=54) and increased physical activity by 44% (n=47). Improved socioeconomic status and reduced social inequality ranked lower underscoring a primary focus on environmental and health outcomes.

Consistent with the self-evaluations of stakeholders' abilities to exercise influence were the reported barriers to sustainable urban development pointing poor coordination and alignment of decisions and policies as major challenge (44% n=47), along with conflict of business and public interests in 43% (n=46), as well as lack or insufficient political support in 39% (n=42), followed by poor or inadequate capacity and understanding of research evidence (38%, n=41), general public awareness (36%, n=39) and underfunding (35%, n=38) revealing major systemic governance and engagement challenges.

The prevailing opinion was that local authorities (90%, n=97) were the most effective agents in advancing sustainable urban development and health, along with communities (71%, n=77) while 48% (n=51) acknowledged the role of national and centralized policy decision making.

Overall results of the survey provided insight into deficiencies limiting effectiveness in urban health management and stakeholders' opinions favouring access to high-quality health-related research evidence to foster active engagement of both public and professional bodies thus providing rationale for validating the concept for reframing integrative HIA approach for sustainable urban development.

An overview of urban environment - public health interactions and exposure patterns across major Bulgarian cities

The overview of the interactions between urban environment and public health as well as the mapping and modeling of exposure patterns clarifies the current data and evidence base. This overview is focused on five of the largest cities, with a particular emphasis on Sofia. We highlight some of the key urban exposures such as air, noise, and light pollution, alongside the characteristics of green spaces and their accessibility.

One of the experiences drawn here together with others is the pilot project "Set an **Urban Standard** - Creation of a Standard for Evaluation and Monitoring of the Quality of the Urban Environment", funded by the "Europe" Program by Sofia municipality in 2017 in which the healthy urban environment was defined as one of the five major thematic spheres for high quality urban environment.

Another flagship experience reflected here, the project "**URBiNAT** - Healthy corridors as drivers of social housing neighbourhoods for the co-creation of social, environmental and marketable NBS" was funded by the EU Horizon 2020 program and provided ground from 2018 for natural experiments of healthy urban environment co-creative regeneration through nature based solutions in the form of green corridors, one of them implemented in Sofia by 2024.

A more focused and thorough approach in the project "Development of a **methodology for air** quality **and** human **health** risk **assessment** in urban areas" that is supported by the Bulgarian National Science Fund from 2021 onwards, helps to build the bridges between multiple disciplines in the sake of more robust air pollution modeling and assessment of its health impacts in terms of current status and future impacts from urban development alternatives.

The project "**Joint effects** of exposures to natural and built environments – informing healthy and sustainable urban development" as part of the "Strategic research and innovation program for the development of Medical University – Plovdiv" and as part of the Establishment of a network of research higher schools via the National plan for recovery and resilience is financed by the European Union – NextGenerationEU. It is a primary effort of all the authors of this paper to dive into the complex and intertwined urban environment - health relations in the major urban areas in Bulgaria.

Additional references made in terms of important screening studies in this knowledge base review are outlooks and compilations of the Health Effects Institute (2022, 2023), the EXPANSE, and UBD Policy Horizon 2020 projects. The latter combines resources with the Methodology for air and health assessment and the Joint effects projects in order to bring synergy in the research efforts for Sofia city.

Table 3 Overview of the HIA evidence for large cities in Bulgaria generated by selected research projects

Type of research / Characteristics	Previous local research - e.g. **'Urban standard'** project (Burov et al., 2023; UBSP, 2021)	Recent international urbanism, social sciences and other interdisciplinary research - e.g. **URBiNAT** project (Tasheva-Petrova et al., 2021; Cardinali, 2024a,b,c; Burov & Tasheva-Petrova, 2025)	Ongoing national multidisciplinary research - e.g. **Methodology for air and health assessment** project (Burov & Brezov, 2022; Brezov & Burov, 2023; Dzhambov et al., 2023; Velizarova et al., 2024; Dimitrova et al., 2025)	Ongoing epidemiological and multidisciplinary research - e.g. **Joint effects** project (Helbich et al., 2024a,b, 2025; Dzhambov et al, 2025a,b)	Recent and ongoing broader EU and comparative case studies epidemiological and multidisciplinary research - e.g. **UBD Policy** project (Iungman et al., 2024; Khomenko et al, 2025)

Studied interactions between urban environment and public health	Comprehensive demonstration in Sofia (several neighborhoods) Health as part of 5 strands of a 4 tiers taxonomy considering indicators representing components and factors for healthy urban environment at the lowest tier and at plot, street segment and quarter level	Co-creation action research in Sofia (Nadezhda district) as well as other EU cities Self-reported health before and after small physical and supportive participatory, social and solidarity nature based solutions (NBS) interventions along green healthy corridor in real scale	Multidisciplinary focus on air pollution as the major environment al risk factor along with other prominent health-relate d exposures in Sofia Dispersion modeling of air pollution and investigating health outcomes, scenario simulations at micro scale	In-depth and multilayered pictures of exposures of 5 biggest cities in Bulgaria Exposure-response functions, socio-economic and spatial disparities in health effects, studied at high resolution	Overall and multilayered picture linking multi city comparative analysis and several cities case studies, one of them Sofia, studied at high resolution neighborhoo d scale
Mapping and modeling and/or evaluation methods and techniques	Rapid assessment based on available data, information and knowledge	Mixed methods and acquisition of self-rated health data together with mapping and geospatial analysis	Focused multilevel air pollution and multi exposure modeling assessment filling gaps, cross-sectional survey for acquisition of self-reported health data	Integrated and focused various pollution and multi-exposure modeling assessment filling gaps, cross-sectional survey for acquisition of self-rated health data	Data science geospatial analysis, synthesis, case study multi-exposure investigation with specific sets of models adapted to every case study

Measured and modeled exposure patterns, thresholds, limits	Available secondary datasets collection, field surveys, geospatial analysis of air quality, noise, greenery, waste, light, water according to national regulations	Available secondary datasets collection, field surveys, behavioral mapping, ex-ante and ex-post cross sectional surveys, geospatial analysis, Structural Equation Modeling (SEM) and other mixed methods with foci on greenery and air quality (PM10, PM2.5, NO_2, and SO_2)	Own inventory, mapping, traffic, emission and dispersion models of air pollution: PM10, PM2.5, NO_2, etc. compared to national, EU and WHO thresholds. Additional co-exposure s such as: noise (road, rail and air traffic noise) from secondary sources; green space: access within 300m of residences.	Official noise measurements based land-use regression and explainable machine learning models compared to European Noise Directive maps with exposure-response curves assessed. Nighttime Light Pollution exposure based on VIIRS satellite data. Air Pollution based on own NO_2 measurements and EXPANSE air pollution data. Greenspace within buffers and via tree cover, NDVI and public spaces. Blue space within buffers.	Air pollution: PM2.5, NO_2) Noise: Road traffic noise levels range from 45-80 dB(A), exceeding WHO guidelines of 53 dB Lden and 45 dB Lnight. Green space: 77% of Sofia's population lacks sufficient greenspace access within 300m of residences. UHI: Average summer UHI effect of 2.5°C Temporal patterns: NO_2 peaks during rush hours (8 a.m. and 5-6 p.m.), with lower concentrations on weekends.
Health burden	Not explicitly addressed but with implicit references	Not explicitly addressed but with implicit references	To be addressed in the final round of well validated dispersion modeling	Health burden estimates of noise for the 5 big cities and others under consideration	Health burden estimates of Sofia with PM2.5, NO2, noise, green and UHI (Khomenko, 2025)
Health promotion, prevention and protection guidelines	Comparison s of (un) favourable exposure, particular urban development , planning and design recommendations, guiding and localisation of public space improvements	Air pollution mitigation by green corridors to improve air quality. Physical activity by accessible green spaces with sports facilities and walking paths. Community engagement by educational programs on environment al stewardship and healthy lifestyles	Measures like low emission zones (LEZ) and traffic reduction (20%) to significantly decrease pollution concentration levels in critical episodes. Integration of green wedges, cycling infrastructure, and transit-oriented development to reduce environmental stressors.	Upcoming set of recommendations based on the exposures and health effects found in each of the 5 cities	Policy briefs and scenarios to be developed as part of overall health promotion guidelines for Sofia

Concept for reintroduction of health impact assessment in Bulgarian cities

In order to enhance the general understanding of the healthy urban environment and its implications in the planning process and content a more holistic definition of its related qualities is needed in the primary EPA and/or in the Health Act along with more specific principles, requirements, capacity arrangements, etc. in a future edited version of the newly proposed by-law. Thus HIAs can become more clearly interpreted against the constitutional rights for healthy environment and wellbeing at a more collective level. Also, healthy aspects of urban planning, design and development can be more clearly treated in the judicial practice in this domain in order to resolve both types of cases under the umbrella of the civil and administrative law. Part of the small gaps can be filled by guidelines, standards and other supportive tools, but due to the contested nature of urban development neither laws nor guidelines are enough. Well targeted and well informed communication can be the key to reintroduction of health and HIAs in the urban arena of knowledge and action, as a cornerstone around the building of the very needed resilient and sustainable communities.

The conceptual model attempts to reframe and propose improvements of existing policies, regulations, tools, and measures. It further attempts to provide grounds for balancing trade-offs between urban development and health protection, by proposing a circular path to safeguarding the wellbeing of Bulgarian city dwellers (Fig. 4). The model is based on a set of definitions, principles and recommendations as follows:

A. Defining „healthy urban living environment“

At the level of the specific legislation - the Environmental protection and Health acts, the concept proposes a definition of “healthy urban living environment” in both legislative texts in order to serve as the basis for urban development policies and principles in this domain. The spirit of the definition proposed is embodied in the notion that “Healthy urban environments do not harm physical health and well-being and promote health-enhancing behaviors and resilience”. Additional proposal is to include in the definition the “Protective characteristics” that limit risk factors, reduce social inequalities, create access to green space and public spaces, support active travel, and promote sustainable resource use leading to overall satisfaction with environmental qualities”.

B. The concept for HIA reintroduction at the bylaw level implies adopting a set of principles:

- The use of sound scientific data and city specific knowledge building as a base;
- Formulation of health-based indicators adapted to the local environment;
- Targeted surveys and consultations with potentially influenced citizens and involved experts;
- Assessment of the needs of vulnerable groups and respect for socio-economic dimensions;
- Adherence to WHO, other international and EU guidelines
- Definition of national norms, thresholds for harmful and targets for protective urban environmental qualities.

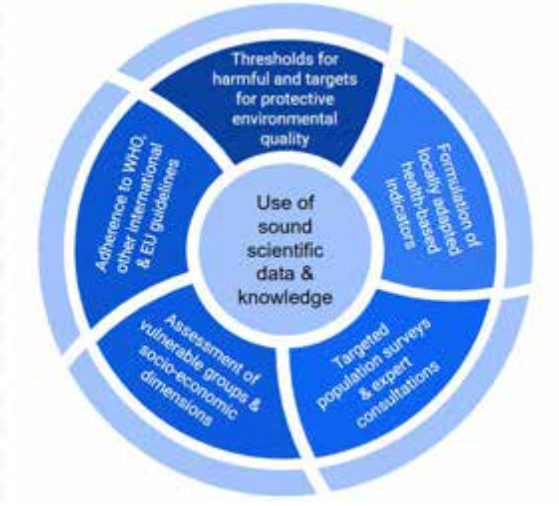

Figure 4 A circular path of HIA reintroduction principles

C. Furthermore, development of instructions is proposed, as well as methodological guidelines and technical standards based on scientific evidence and good practice.

Improved understanding of multidisciplinary issues and provision of references and resources for health protection is a more soft emphasis which could be implemented by the National Centre for Public Health and Analyses and the Regional Health Inspectorates in partnership with academia and professional organizations.

D. It is highly recommended that regulations and plans are updated regularly, and their implementation is monitored and controlled more closely.

Additional synchronisation of the HIA regulations with other environmental and development regulations and differentiation of the levels of complexity in the elaboration of spatial plans are also important aspects that can better direct the implementation of healthy urban planning and evaluation efforts at the appropriate level of initiative, mandate and competence.

Conclusion

Healthy urban planning should be both a goal ensuring the well-being and civilized continuity of urban life and a procedural mechanism driven by actual evidence and enhanced participatory governance. Advanced tools like geospatial analytics, mixed-method approaches, machine learning, and natural language processing enhance the capability of HIA to provide timely, context-sensitive insights and feedback loops, improving communication, saving time and providing precision of urban (re)development endeavors. Efficient procedures and equitable frameworks are essential for delivering health-promoting environments, particularly in post-transitional and contradictory contexts with many external and internal players like Bulgaria.

The proposed revitalized HIA agenda may support cities in staying livable and becoming more inclusive, resilient, and health-supportive spaces for current and future generations. Thus HIA can be a crucial instrument for avoiding the double spending of financial resources, time, energy and resource input as well as human efforts to overcome critical urban health issues while observing processes of urban decay.

Stimulating a wider and deeper discussion on the key principles for healthy and sustainable development of the urban living environment as well as the health support systems in decision making affecting urban development, planning and design is a necessity for Bulgaria. These decision making systems can benefit from a set of tools and interlinkages including qualitative and quantitative assessment of the expected impact, from planned development and regeneration, on public health in terms of morbidity, mortality and well-being, as well as associated socio-economic burden. Emerging platforms for sharing recent knowledge base and data spaces combining spatial data infrastructure and various services can help give confidence in HIA in times of multilevel challenges to our cities.

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References

Barton, H.; Grant, M., 2006. A health map for the local human habitat. The Journal of the Royal Society for the Promotion of Health, 126(6), pp. 252-253.

Brezov, D. and Burov, A. (2023) 'Ensemble Learning Traffic Model for Sofia: A Case Study', Applied Sciences, 13(8), p. 4678. Available at: https://doi.org/10.3390/app13084678.

Burov, A. and Brezov, D. (2023) 'Transport Emissions from Sofia's Streets - Inventory, Scenarios, and Exposure Setting', Lecture Notes in Networks and Systems. Springer International Publishing. Available at: https://doi.org/10.1007/978-3-031-26754-3_20.

Burov, A., Madzhirski, V., Yolova, M., Mutafchiiska, I. (2023) 'The Implementation of an "Urban Standard" for Monitoring and Evaluation of the Urban Environment', Annual of the University of Architecture, Civil Engineering and Geodesy Sofia, 56(2), p. 543. Available at: https://old.uacg.bg/UserFiles/File/UACEG_Annual/2023/Брой%202/A13.pdf.

Burov, A. and Tasheva-Petrova, M. (2025) 'Mitigation of Air Pollution and NBS'. In Ferreira, I., Caitana, B., Nunes, N. (Eds.) 'Urban Inclusive and Innovative Nature: Fundaments and Practices for the Co-creation of Nature-based Cities', Fondazione Giangiacomo Feltrinelli, Milano, ISBN 978-88-6835-519-7. Available at: https://hdl.handle.net/10316/118621.

Cardinali, M. et al. (2024a) 'Examining green space characteristics for social cohesion and mental health outcomes: A sensitivity analysis in four European cities', Urban Forestry & Urban Greening, 93, p. 128230. Available at: https://doi.org/10.1016/j.ufug.2024.128230.

Cardinali, M. et al. (2024b) 'The relation between proximity to and characteristics of green spaces to physical activity and health: A multi-dimensional sensitivity analysis in four European cities', Environmental Research, 241, p. 117605. Available at: https://doi.org/10.1016/j.envres.2023.117605.

Cardinali, M. et al. (2024c) 'Urban green spaces, self-rated air pollution and health: A sensitivity analysis of green space characteristics and proximity in four European cities', Health & Place, 89, p. 103300. Available at: https://doi.org/10.1016/j.healthplace.2024.103300.

Castro, C. G., Trevisan, A. H., Pigosso, D. C. A., & Mascarenhas, J. (2022). The rebound effect of circular economy: Definitions, mechanisms and a research agenda. Journal of Cleaner Production, 345, 131136. https://doi.org/10.1016/j.jclepro.2022.131136.

Center for Social Studies (CES) (2025). "URBiNAT - Healthy corridors as drivers of social housing neighbourhoods for the co-creation of social, environmental and marketable NBS". Available at: https://urbinat.eu/.

Dimitrova, R. et al. (2025) 'Implementation of Coupled Regional-to-local Scale Modelling System in Bulgaria – Air Quality Study for the City of Sofia', Proceedings of the Bulgarian Academy of Sciences, 78(3). Available at: https://doi.org/10.7546/crabs.2025.03.09.

Dyer, G. M. C., Khomenko, S., Adlakha, D., Anenberg, S., Behnisch, M., Boeing, G., Esperon-Rodriguez, M., Gasparrini, A., Khreis, H., Kondo, M. C., ... Nieuwenhuijsen,

M. (2024). Exploring the nexus of urban form, transport, environment and health in large-scale urban studies: A state-of-the-art scoping review. Environmental Research, 257, 119324. https://doi.org/10.1016/j.envres.2024.119324.

Dzhambov, A.M. et al. (2023) 'Joint associations and pathways from greenspace, traffic-related air pollution, and noise to poor self-rated general health: A population-based study in Sofia, Bulgaria', Environmental Research, 231, p. 116087. Available at: https://doi.org/10.1016/j.envres.2023.116087.

Dzhambov, A.M. et al. (2025) 'Physical urban environment and cardiometabolic diseases in the five largest Bulgarian cities', International Journal of Hygiene and Environmental Health, 264, p. 114512. Available at: https://doi.org/10.1016/j.ijheh.2024.114512.

Dzhambov, A.M. et al. (2025) 'Exposure-response relationships between road traffic, railway, and aircraft noise and annoyance in Bulgarian cities', Environmental Research, 269, p. 120879. Available at: https://doi.org/10.1016/j.envres.2025.120879.

Dzhambov, A.M. et al. (2023) 'Joint associations and pathways from greenspace, traffic-related air pollution, and noise to poor self-rated general health: A opulation-based study in Sofia, Bulgaria', Environmental Research, 231, p. 116087. Available at: https://doi.org/10.1016/j.envres.2023.116087.

European Commission (2019a). Commission staff working document evaluaton of the Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the einvironment. SWD(2019) 413 final. Available at: https://circabc.europa.eu/ui/group/3b48eff1-b955-423f-9086-0d85ad1c5879/library/d4 79c54e-d1c2-4f7f-a40e-4e0b41f6ff39/details?download=tr.

European Commission (2019b). National transposition measures communicated by the Member States concerning: Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment. Available at: https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32001L0042&qid=14871 72800769.

European Commission: Directorate-General for Environment, Lundberg, P., McNeill, A., McGuinn, J., Cantarelli, A., Vona, L., Cinova, D., Truc, M., Kolaric, S., White, O., Sadauskis, R., Taylor, C., Eales, R., Perrin, A., & Noonan, A. (2025). Study supporting the preparation of the report on the application and effectiveness of the

SEA Directive (Directive 2001/42/EC) : final study, Publications Office of the European Union. Available at: https://data.europa.eu/doi/10.2779/1615072.

European Environment Agency. (2010). The European environment: state and outlook 2010 : synthesis. Publications Office. https://doi.org/10.2800/45773.

Eurostat. (2025). Deaths and crude death rate [Dataset]. Eurostat. https://doi.org/10.2908/TPS00029.

EU (2001). Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment (OJ L 197, 21.7.2001, pp. 30-37). Available at: http://data.europa.eu/eli/dir/2001/42/oj.

Hajat, A., Hsia, C., & O'Neill, M. S. (2015). Socioeconomic disparities and air pollution exposure: A global review. Current Environmental Health Reports, 2(4), 440–450. https://doi.org/10.1007/s40572-015-0069-5.

Health Effects Institute (2022) Trends in Air Quality and Health in Bulgaria: A State of Global Air Special Report. Boston, MA:Health Effects Institute. ISSN 2578-6881.

Available at:
https://www.stateofglobalair.org/sites/default/files/documents/2022-06/soga-southeast-europe-bulgaria-report.pdf.

Health Effects Institute (2023) Spatial Bibliography - Southeast Europe. Available at: https://www.healtheffects.org/global/spatial-bibliography.

Health Effects Institute (2024). Bulgaria air pollution and health country profile. https://www.stateofglobalair.org/resources/countryprofiles.

Helbich, M. et al. (2024) 'Sociodemographic inequalities in residential nighttime light pollution in urban Bulgaria: An environmental justice analysis', Environmental Research, 262, p. 119803. Available at: https://doi.org/10.1016/j.envres.2024.119803.

Helbich, M. et al. (2024) 'Sleep problems mediate the association between outdoor nighttime light and symptoms of depression and anxiety: A cross-sectional, multi-city study in Bulgaria', Environmental Research, 263, p. 119897. Available at: https://doi.org/10.1016/j.envres.2024.119897.

Helbich, M. et al. (2025) 'Traffic noise assessment in urban Bulgaria using explainable machine learning', Sustainable Cities and Society, 120, p. 106169. Available at: https://doi.org/10.1016/j.scs.2025.106169.

Iungman, T. et al. (2024) 'The impact of urban configuration types on urban heat islands, air pollution, CO2 emissions, and mortality in Europe: a data science approach', The Lancet Planetary Health, 8(7), pp. e489–e505. Available at: https://doi.org/10.1016/s2542-5196(24)00120-7.

Krefis, A., Augustin, M., Schlünzen, K., Oßenbrügge, J., & Augustin, J. (2018). How Does the Urban Environment Affect Health and Well-Being? A Systematic Review. Urban Science, 2(1), 21. https://doi.org/10.3390/urbansci2010021.

Khomenko, S. et al. (2025) 'Health burden and inequities of urban environmental stressors in Sofia, Bulgaria', Environmental Research, 279, p. 121782. Available at: https://doi.org/10.1016/j.envres.2025.121782.

Medical University Plovdiv (MUP) (2025). "Joint effects of exposures to natural and built environments – informing healthy and sustainable urban development".

Available at:
https://nimu.mu-plovdiv.bg/nimu_root/en/projects/joint-effects-of-exposures-to-natural-and-built-environments-informing-healthy-and-sustainable-urban-development/.

MEW (2025a). Register of SEAs (in Bulgarian). Available at: https://registers.moew.government.bg/eo.

Mouratidis, K. (2021). Urban planning and quality of life: A review of pathways linking the built environment to subjective well-being. Cities, 115, 103229. https://doi.org/10.1016/j.cities.2021.103229.

Mueller, N., Daher, C., Rojas-Rueda, D., Delgado, L., Vicioso, H., Gascon, M., Marquet, O., Vert, C., Martin, I., & Nieuwenhuijsen, M. (2021). Integrating health indicators into urban and transport planning: A narrative literature review and participatory process. International Journal of Hygiene and Environmental Health, 235, 113772. https://doi.org/10.1016/j.ijheh.2021.113772.

Mueller, N., Anderle, R., Brachowicz, N., Graziadei, H., Lloyd, S. J., de Sampaio Morais, G., Sironi, A. P., Gibert, K., Tonne, C., Nieuwenhuijsen, M., & Rasella, D. (2023). Model choice for quantitative health impact assessment and modelling: An expert consultation and narrative literature review. International Journal of Health Policy and Management, 12, 7103. https://doi.org/10.34172/ijhpm.2023.7103.

Parrique T., Barth J., Briens F., C. Kerschner, Kraus-Polk A., Kuokkanen A., Spangenberg J.H. (2019). Decoupling debunked: Evidence and arguments against green growth as a sole strategy for sustainability. European Environmental Bureau.

Popov, I., Hlebarov, I. (2022). Is there nitrogen dioxide air pollution in Sofia? Results of measurements of Za Zemyata in 2021 [report in Bulgarian]. Available at: https://www.zazemiata.org/wp-content/uploads/2022/05/Za-Zemyata-Doklad-NO2-On line.pdf.

Sofiplan (2025). General spatial development plan and Strategic environmental assessment. Available at: https://sofiaplan.bg/portfolio/oup-sofia/.

Sofia University (SU) (2025). "Development of a methodology for air quality and human health risk assessment in urban areas". Available at: https://mg.phys.uni-sofia.bg/projects/AirQuality/air-quality-project-web_en.html.

Tasheva-Petrova, M. et al. (2021) 'Re-claiming space for public life: messages from the northwestern periphery of Sofia', Urbani izziv, 32(supplement), pp. 91–105.
Available at: https://doi.org/10.5379/urbani-izziv-en-2021-32-supplement-6.

UNECE (2025). Documents. Available at: https://unece.org/env/pp/cc/documents#accordion_2.

Union of Bulgarian Spatial Planners (UBSP) (2025). "Set an Urban Standard - Creation of a Standard for Evaluation and Monitoring of the Quality of the Urban Environment". Available at: https://bgplanning.org/projects/gradski-standart/.

Union of Bulgarian Spatial Planners (UBSP) (2021). "Analysis of the southern part of Lozenets District". Available at: https://sofiaplan.bg/portfolio/lozenets-analysis/.

Velizarova, M. et al. (2024) 'Evaluation of Emission Factors for Particulate Matter and NO2 from Road Transport in Sofia, Bulgaria', Atmosphere, 15(7), p. 773. Available at: https://doi.org/10.3390/atmos15070773.

Webster, P., & Sanderson, D. (2012). Healthy Cities Indicators—A Suitable Instrument to Measure Health? Journal of Urban Health, 90(S1), 52–61. https://doi.org/10.1007/s11524-011-9643-9.