Creating healthy and sustainable cities: what gets measured, gets done

Since the first *Lancet* Series on urban design, transport, and health (Series 1) was published in 2016, the urgency to make the transition to healthy and sustainable cities worldwide has intensified. That year, the UN's Sustainable Development Goals[1] for promoting prosperity while protecting the planet and ensuring equity came into force. WHO also released its Shanghai Declaration on promoting health in the 2030 Agenda for Sustainable Development. At WHO Global Conference on non-communicable diseases (NCDs) in 2017, heads of states reiterated their commitment to reduce premature mortality from NCDs by a third by 2030. In 2018, WHO published the Global Action Plan for Physical Activity, which featured recommendations to create active environments. Cobenefits of integrated city planning policies for individual and planetary health are now recognised globally, and scientific evidence about rapidly changing earth systems and increasingly extreme weather has reinforced the urgency to transition to net-zero-emission cities.[2]

Series 1[3] highlighted evidence supporting pedestrian-friendly and cycling-friendly, higher-density compact cities with proximate shops, services, and transit. In that Series, we identified eight integrated urban systems policies that work together to create eight intervention foci—the 8D's—to develop more compact cities that enable sustainable mobility, reduce NCDs and road trauma, and manage urbanisation.[3] Three of these interventions relate to regional planning (destination accessibility; distribution of employment; and demand management to reduce driving) and five relate to local

See **Series** pages e882, e895, e907, and e919

For **WHO Global report on urban health** see https://apps.who.int/iris/handle/10665/204715

For more on **WHO Global Conference on NCDs** see https://www.who.int/conferences/global-ncd-conference/montevideo-report.pdf?ua=1

For **WHO Global Action Plan for Physical Activity** see http://apps.who.int/iris/bitstream/handle/10665/272722/9789241514187-eng.pdf

For more on **health, environment, and climate change** see https://www.who.int/publications/i/item/9789240000377

	Indicators from Series 1	Indicators assessed in Series 2
Policy indicators (ie, policies and legislation)		
Integrated transport and urban planning	National and state transport and urban planning legislation requires integrated transport and urban planning actions to create healthy and sustainable cities and regular review of progress	Paper 1[4]
Air pollution	National and state air pollution legislation seeks to protect and improve air quality to promote the health of urban populations	Paper 1[4]
Destination accessibility	National and state transport and urban planning legislation requires coordinated planning of transport, employment, land use, and infrastructure that ensures access by public transport	Paper 1[4]
Distribution of employment	Urban planning and design codes require a balanced ratio of jobs to housing (eg, from 1:0·8 to 1:1·2)	Paper 1[4]
Demand management	Urban planning, building codes, and local government policies limit car parking and price parking appropriately for context	Paper 1[4]
Design	Urban design codes create pedestrian-friendly and cycling-friendly neighbourhoods, requiring highly connected street networks, pedestrian and cycling infrastructure, and public open space; lot layouts maximise natural surveillance	Paper 1[4] (lot layouts were not assessed, due to data unavailability across cities)
Density	Urban design codes require minimum and maximum context-specific housing densities, including higher-density development around activity centres and transport hubs	Paper 1[4]
Distance to public transport	Urban design codes require frequent service public transport to be within 400–800 m of residential walkable catchments	Paper 1[4]
Diversity	Urban design codes require a diverse mix of housing types and local destinations needed for daily living	Not measured separately; partly covered by other policy indicators (eg, destination accessibility and design)[5]
Desirability	Urban design codes incorporate crime prevention through urban design principles, manage traffic exposure, and establish urban greening provisions	Not measured separately; partly covered by other policy indicators (eg, design, demand management, air pollution)[5]
Walking and cycling participation and public transport use targets	Not proposed in Series One	Paper 1[4]
Government transport investment		
Transport infrastructure investment by mode	Percentage of total government transport expenditure in a given financial year spent on pedestrian infrastructure, cycling infrastructure, public transport, and road infrastructure	Paper 1[4]

(Table continues on next page)

	Indicators from Series 1	Indicators assessed in Series 2
(Continued from previous page)		
Spatial indicators†		
Urban design and transport features		
Public transport access	Percentage of population living within 400–800 m of high-frequency public transport	Paper 3;[5] percentage of population living within 500 m of a frequently serviced public transport stop†
Employment	Percentage of population with employment within 30 min of their home by walking, cycling, or public transport	Not measured, as comparable data available not for all cities
Distribution of employment	Urban planning and design codes require a balanced ratio of jobs to housing (eg, from 1:0·8 to 1:1·2)	Not measured, as comparable data not available for all cities
Transport infrastructure	Ratio of roads (km) to footpaths (km) and designated cycle lanes (km)	Not measured, as comparable reliable data not available for all cities
Design	Street connectivity (eg, ped sheds‡ ≥0·6 within 0·8–1·2 km) of desintations eg, shops, schools, services, and transport hubs	Paper 3;[5] street intersection density in the local walkable neighbourhood of residence*
Density	Dwellings per area: within 1·2 km of activity centres and public transport hubs, and in urban fringe developments	Paper 3;[5] population density in the local walkable neighbourhood of residence*
Distance to transit	Percentage of population living within 400 m of a bus stop and 800 m of a rail stop	Paper 3;[5] percentage of population living within 500 m of any public transport stop†
Destinations	Percentage of (urban) land area allocated to destinations required for daily living	Paper 3;[5] percentage of population living within 500 m of a fresh food market, a convenience store, and public transport (ie, any stop and a stop with a high-frequency service)
Open or green space	Percentage of (urban) land area allocated to open or green space	Paper 3;[5] Percentage of population living within 500 m of a public open space (ie, any public open space and any public open space than 1·5 hectares)
Walkability	Not proposed in Series 1	Paper 3;[5] combined population density, street intersection density, and daily living destinations in local neighbourhood
Transport outcomes		
Trip mode share	Proportion of total and commuting trips made by walking, cycling, public transport, and private motor vehicle	Not measured as indicators; however, paper 1[4] measured policy targets for walking, cycling, and public transport use; and paper 2[6] estimated prevalence of any walking for transport in 14 cities in 10 countries

*Local walkable neighbourhood defined as the intersection between urban neighbourhood grid and 1 km extent of pedestrian street network from sample address points. †Choice of final indicators and distance thresholds for Series 2 were informed by available data and the indicator frameworks for UN Sustainable Development Goals[3] or UN Habitat's New Urban Agenda. ‡Ratio of straight line distance buffer to street network distance buffer

Table: **City planning policy and spatial indicators proposed in the first urban design, transport, and health Series**

urban design (design of pedestrian-friendly and cycling-friendly movement networks; optimising residential density; reducing distance to public transport; increasing diversity of housing and mixed land uses; and enhancing desirability of active transport modes). The 8D's work together to create built environments that influence transport mode choices, which in turn affect individual, social, and environmental risk factors associated with health and wellbeing. Series 1 proposed city planning policy and spatial indicators (table) to benchmark and monitor progress towards achieving healthy and sustainable cities.

This second Series on urban design, transport, and health (Series 2) moves beyond describing why societies need to make the transition to healthier, more sustainable cities, to focus on how and what must change. A glossary of terms is available in the appendix. Series 2 shows the feasibility of assessing health-supportive city planning policies and creating spatial indicators of urban design and transport features, by use of standardised methods across cities worldwide. To do this, we formed the multidisciplinary Global Healthy and Sustainable City-Indicators Collaboration, with expertise in public health, urban and transport planning, urban design, architecture, computer and geospatial science, behavioural science, statistics, epidemiology, complex systems science, and public policy.

See Online for appendix

The goal of Series 2 is to facilitate the development of a global system of policy and spatial indicators for healthy and sustainable cities. Building on methodologies developed in Australia,[7,8] we measured a modified list of the indicators recommended in Series 1 for 25 cities in 19 middle-income and high-income countries. We sought to answer multiple questions: (1) Is it feasible to measure policies in cities worldwide? (2) If so, do cities have city planning policies that will lead to healthy and sustainable cities?[4] (3) What are the thresholds for urban design and transport features to achieve active and

sustainable lifestyles?[6] (4) Is it feasible to consistently measure spatial indicators of urban design and transport features that enable active and sustainable lifestyles in cities worldwide? (5) If so, are there inequities in access to supportive environments between and within cities?[5]

Given the rapidly evolving global challenges that have arisen since our original framework and indicators were published in 2016, the final paper in Series 2[9] considers "where to next?" It updates and expands our 2016 framework of the pathways through which city planning affects ecosystem, human, and planetary health and recommends additional city planning indicators to benchmark and monitor cities. It then outlines global, national, regional, and local actions urgently needed to move from evidence to implementation.

Series 2 underscores that integrated city planning has never been more important and identifies actions that must be taken. It is well known that what gets measured, gets done. We therefore provide open-source tools to facilitate measurement of city planning policies and interventions and to enable immediate action.[5,10] Our vision is that evidence-informed indicators measuring city planning policies and outcomes will be used worldwide to benchmark and monitor progress to hasten the transition to a healthy, sustainable future.

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1 UN General Assembly. Resolution adopted by the General Assembly: transforming our world: the 2030 agenda for sustainable development. New York: United Nations, Oct, 2015.

2 IPCC. Summary for policymakers. In: Masson-Delmotte V, Zhai P, Pirani A, et al, eds. Climate change 2021: the physical science basis. Contribution of working group I to the sixth assessment report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press (in press).

3 Giles-Corti B, Vernez-Moudon A, Reis R, et al. City planning and population health: a global challenge. *Lancet* 2016; **388:** 2912–24.

4 Lowe M, Giles-Corti B, Boeing G, et al. Assessing urban design and transport planning policy to create healthy and sustainable cities: indicators for 25 cities worldwide. *Lancet Global Health* 2022; **10:** e882–94.

5 Boeing G, Lowe M, Giles-Corti B, et al. Using open data and open-source software to measure and map spatial indicators of urban design and transport features for healthy and sustainable cities in 25 cities worldwide. *Lancet Global Health* 2022; **10: e**907–18.

6 Cerin E, Giles-Corti B, Lowe M, et al. Determining optimal thresholds for spatial indicators of healthy and sustainable cities: findings from the IPEN Adult study. *Lancet Global Health* 2022; **10:** e895–906.

7 Arundel J, Lowe M, Hooper P, et al. Creating liveable cities in Australia: mapping urban policy implementations and evidence-based national liveability indicators. Melbourne: Centre for Urban Research, RMIT University, 2017.

8 Alderton A, Higgs C, Davern M, et al. Measuring and monitoring liveability in a low-to-middle income country: a proof-of-concept for Bangkok, Thailand and lessons from an international partnership. *Cities Health* 2021; **5:** 320–28.

9 Giles-Corti B, Moudon AV, Lowe M, et al. What next? An expanded view of city planning and global health, and the need for evidence-informed policy to be implemented and monitored. *Lancet Global Health* 2022; **10:** e919–26.

10 Liu S, Higgs C, Arundel J, et al. A generalized framework for measuring pedestrian accessibility around the world using open data. *Geographical Analysis* 2021; published online May 19. https://doi.org/10.1111/gean.12290