Urban systems complexity in sustainability and health: an interdisciplinary modelling study

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Abstract

Background Improving urban health and sustainability raises complex questions that are best addressed through interdisciplinary and even transdisciplinary approaches, in which scientific research and analysis and stakeholder engagement have important roles. In this study we report pilot work in Nairobi (Kenya) and London (UK) that uses innovative methods to integrate qualitative and quantitative modelling to provide evidence to support policy development for health and sustainability in these cities.

Methods We used two primary modelling methods, system dynamics and microsimulation, and sought to understand the value of these tools in combination to support policy decisions. System dynamics was used to establish an aggregated and non-linear causal map of the interconnections between diverse variables, and thus to gain insight into the policies and specific processes that need to be examined in further depth. System dynamics was a key tool for city-level stakeholder engagement. In part informed by the outcome of the system dynamics process, microsimulation was then used to quantify local effects on health of selected policy options. The results were mapped using geographic information systems methods.

Findings The combination of system dynamics and microsimulation models provided a framework that enhanced collective knowledge about the interrelationships of policy decisions, funding, public awareness, and environmental and health effects. Our initial participatory system dynamics work on air pollution in Nairobi found that a combination of policies that focus on households and outdoor air could reduce household air pollution by about 50%, leaving it still above WHO-recommended levels. Yet, the investments in monitoring and health impact assessment have the potential to trigger reinforcing mechanisms that create synergies among existing policies and increase the return on investment. Preliminary 106-year microsimulation runs of the effects of $PM_{2.5}$ in London revealed that anthropogenic emissions are associated with about 2300 incident cases of ischaemic heart disease annually. The two methods appeared to have valuable complementarity in their focus on aggregated dynamics at the policy level versus local policy effects.

Interpretation The use of system dynamics can produce a quantitative model of the policy implementation process, including the organisational barriers and opportunities for change. This can be extended to include aggregate outputs from other models to quantify a more holistic and high-level quantitative model of the dynamics of selected policy questions. Together, these methods can estimate regional environmental and local health effects of selected policies, but also inform about overcoming the barriers to these policies.

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NZ, PS, MD, and PW wrote the abstract. All authors were involved in the underlying research; PS and KD contributed particularly to the quantitative modelling.

Declaration of interests

We declare no competing interests.

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