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REVIEW

REVISED The epidemiologic case for urban health: conceptualizing and measuring the magnitude of challenges and potential benefits

[version 2; peer review: 1 approved, 2 approved with reservations]

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Abstract

We discuss how epidemiology has been and can continue to be used to advance understanding of the links between urban areas and health informed by an existing urban-health conceptual framework. This framework considers urban areas as contexts for health, determinants of health and modifiers of health pathways, and part of a complex system that affects health. We highlight opportunities for descriptive epidemiology to inform the context of urban health, for example, by characterizing the social and physical environments that give rise to health and the actions that change those conditions. We then describe inferential tools for evaluating the impact of group-level actions (e.g., interventions, policies) on urban health, providing some examples, and describing assumptions and challenges. Finally, we discuss opportunities and challenges of applying systems thinking and methods to advance urban health. While different conceptual frames lead to different insights, each perspective demonstrates that urban health is a major and growing challenge. The effectiveness of urban health knowledge, action, and policy as the world continues to urbanize can be informed by applying and expanding upon research and surveillance methods described here.

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REVISED Amendments from Version 1

We made a few minor changes to the previous version upon considering the generous feedback from the reviewers. We added additional information and resources related to policy surveillance. We also added a few more existing resources for local health and policy data. In addition, we discussed strengths and limitations of small-area-estimation (SAE) methods further and added some notes on Bayesian SAE methods. Finally, we included more discussion on existing systems-thinking frameworks integrating the health of human populations, animals, and climate resilience, such as planetary health and One Health.

Any further responses from the reviewers can be found at the end of the article

Key messages

- The health of urban residents is a major component of global health and will become more important with continuing urbanization.
- Urban areas share common health-relevant environmental and social features, but the health of urban residents and the impact of urban living on health vary between and within cities.
- As a previously published conceptual framework articulates, the links between urban environments and population health can be conceptualized in various ways, including as the setting in which population health occurs, as a cause of population health, and as part of a complex system that shapes population health. Each conceptualization raises distinct challenges and opportunities regarding measurement of scale and impacts.
- Classical tools of descriptive epidemiology remain important for the study of urban health, and more complete health-outcome data on health is needed at the city- and within-city scales.
- Where direct observation is not feasible, health-impact modeling and small-area estimation show promise for advancing the description of urban health outcomes at high spatial resolution.
- There is a need for higher resolution and more systematic measurement of the physical, social, and policy environments that affect urban health, a task that can be considered within the purview of descriptive epidemiology.
- Research on the impact of actions and interventions on urban health and health equity interventions is limited. Evaluating these actions using longitudinal methods for group-level data should continue.

1. Introduction**1.1 The importance of urban health**

As the proportion of humanity living in cities continues to rise, the health of people living in urban areas will represent an increasingly important component of global health.¹ In 2018, the share of the world's population residing in urban areas was 55% and is expected to increase to 60% by 2030.¹ Urbanization (the process of an area becoming more urban) is accelerating in particular in low- and middle-income countries in Asia and Africa.¹ A clear implication of global urbanization trends is that improving public health globally will require a major focus on health in urban areas.² However, the scale of current and future urban health challenges and opportunities is not well characterized and depends on assumptions about the nature of the relationships between cities and health and the scope of urban health action.

As a preliminary note on language, an *urban area* has been defined “as a geographical space characterized by a continuous urban settlement.”³ The phrase is commonly used in a more general sense than *city*, which can refer to a discrete urban area defined with administrative boundaries.² For a rigorous discussion of these terms, we recommend Chapter 1 of *Urban Public Health* by Diez-Roux² and Tonne et al (2021).⁴ In this article, we usually use the more general term—*urban area*—but occasionally use the word *city* as a rhetorical shorthand.

Urban areas present both challenges and opportunities for public health.^{5–7} Compared with rural areas, urban areas can promote health through higher standards of living and better access to resources and services, including healthcare services.^{4,8,9} Nevertheless, characteristics common to many urban environments can also harm health, including air pollution;¹⁰ noise pollution; heat exacerbated by urban heat islands;¹¹ inadequate green space; high availability of nutrient-poor, calorie-dense food; and unsafe transportation systems resulting in road traffic injuries and discouraging physical activity.^{4,12} Urban areas are also vulnerable to some infectious diseases. Some, such as COVID-19,¹³ may

spread rapidly in areas with high population density and connectivity.¹² Others, such as malaria, have historically been more common in rural areas,¹⁴ but climate change and landscape modifications including deforestation are changing spatial patterns of vector-borne diseases, increasing their occurrence in urban areas.¹⁵

While urban areas can share common health-relevant environmental and social features, cities are distinct, and the health of urban residents—and the impact of urban living on health—varies both between and within cities.^{16,17} Unequal exposure over time to social, political, and environmental conditions gives rise to health inequities in urban populations by characteristics such as income and wealth, residential neighborhood, race and ethnicity, age, disability, gender identity, sexual orientation, or migration status.¹⁷ Ultimately, variation in health between and within cities reveals an opportunity: urban areas can be designed and managed to promote health and health equity. Furthermore, in the context of global climate change, strategies to improve health in cities can have co-benefits for climate-change mitigation and adaptation.^{4,18–20} Given this opportunity, there is a need for a clearer understanding of how urban environments and the forces that change them affect public health and of the scale of the health challenges and opportunities inherent in the urban context.

1.2 The role of epidemiology

Many disciplines will contribute to this needed understanding, and epidemiologists, those who study the distribution and determinants of health in populations, are well-equipped to contribute in several ways. Some tools from epidemiology, in particular descriptive epidemiology, have an established history of informing urban health. Other more contemporary topics in epidemiology, such as methods for causal inference, have yet to realize their potential in helping to answer urban-health questions. At the same time, the discipline may be well-suited to advance urban-health knowledge in ways traditionally not under its purview, such as the surveillance of the urban physical and policy environment. In this article, we discuss how epidemiology has been and can continue to be used to advance understanding of the links between urban areas and health informed by an existing urban-health conceptual framework. We then propose actions needed to continue to advance this understanding.

2. Conceptualizing and measuring urban health

2.1 A framework relating urban areas and health

Urban-health scholars have proposed various frameworks to represent and explain the links between urban environments and population health.^{4,21–26} In the framework by Diez Roux presented in Chapter 3 of *Urban Public Health*, the links are conceptualized in four inter-related ways.²⁵ First, urban areas are contexts for health. That is, they are settings in which population health occurs. Second, urban areas are causes or determinants of health. These place-based causes occur at various levels, for example, the neighborhood (e.g., features of its built environment) or the city (e.g., housing policy). Third, and related to the second, urban areas can modify or reinforce individual-level health pathways. For example, genetic susceptibility to obesity can be modified by the neighborhood food environment.²⁷ Fourth—and encompassing each of the above—urban areas are part of complex systems that shape population health.^{4,22,28}

Measuring the magnitude of urban-health challenges through each of these lenses has value for researchers, policy-makers, and advocates. For instance, viewing urban areas as *contexts* for health allows us to describe and compare health outcomes across different urban environments, highlighting disparities and identifying areas to prioritize for intervention. Understanding urban areas as *determinants* and *modifiers* of health enables us to investigate the causal impacts of specific urban characteristics and interventions on health outcomes and to inform action to change those characteristics. Finally, adopting a *complex systems* perspective allows us to appreciate the interconnectedness of factors influencing urban health, informing the development of holistic interventions at the structural level that can be mutually beneficial for many domains of population health, ecosystems, and climate resilience.²⁹

2.2 Urban areas as contexts for health

2.2.1 Describing health-related states and behaviors in urban populations

The most conceptually straightforward link between urban areas and health is the occurrence of diseases, health-related states, and behaviors among individuals living in urban areas. Measuring these outcomes in urban areas is important for planning and resource allocation, monitoring progress on health targets over time, comparing the distribution of health between groups, generating hypotheses, and identifying opportunities for intervention. This task has traditionally been undertaken by public health surveillance systems (such as vital statistics registries and large-scale cross-sectional surveys), cohort studies, and other tools of descriptive epidemiology. For example, national registries have been used to compare cancer incidence between urban and rural areas over time in the United States.^{30,31} Vital registration data can be standardized and harmonized to allow for cross-city comparisons, such as in the SALURBAL study that described within-country heterogeneity in life expectancy across Latin American cities.¹⁶

A barrier to descriptive epidemiology in urban areas is that information is commonly collected to be representative of an administrative unit above the city (for example, of a state, province, or country). For example, the Global Burden of Disease project, which comprehensively describes the occurrence, mortality attributable to, and disability attributable to hundreds of diseases, injuries, and risk factors, presents information at the country level.³² Such comprehensive descriptive epidemiology does not exist for urban areas. Assuming 55% of the world's population lives in urban areas¹ and that there were 55.4 million deaths in 2019,³³ then a crude calculation assuming the number of deaths in urban areas is proportional to their share of the population suggests about 30.5 million deaths (0.55×55.4 million) occurred in urban areas in 2019. Currently, only crude calculations such as this are available, and global estimates have not accounted for urban-versus-rural differences in mortality for reasons such as urban-rural differences in age structure or exposure to risks. The lack of urban-specific estimates of the health burden or of the scale of the health benefits that might result from relevant interventions poses challenges for allocating appropriate financial, institutional, and human resources to urban health action.

While more work is needed to comprehensively describe the urban burden of ill health, existing information can serve as a useful guide. When direct measurement of health outcomes (e.g., through surveys) in cities is not feasible, two approaches hold promise for advancing descriptive epidemiology within and across urban areas: health-impact modeling and small-area estimation. Health-impact modeling is often used to project the health impacts of alternative scenarios. It can also be used to estimate the burden of dimensions of health attributable to the status-quo scenario. For example, health-impact modeling was used to estimate that exposure to air pollution among residents of 13,160 urban areas globally resulted in 1.8 million excess deaths in 2019.⁴⁰ While valuable, health-impact modeling studies can rely on strong assumptions, for example that health effects estimated in one location can apply to the area of interest. As we discuss further below, health effects can be context dependent.²⁵ The validity of health-impact assessment may benefit from more explicitly considering the extent to which effects are transportable from one context to another.³⁴

As health outcomes can vary considerably between and within urban areas,¹⁷ methods aiming to estimate health outcomes at a fine geographic scale are important. Small-area estimation (SAE) is a suite of such methods. SAE methods estimate outcome measures (e.g., disease prevalence) at a unit of geography beneath the level where the measure is known (e.g., from a U.S. state to a county).³⁵ SAE methods include, for example, non-parametric methods that use measured associations between the outcome and demographic characteristics at the larger geographic unit (e.g., U.S. states) and apply those associations to smaller units where the outcome is not measured (such as counties), spatial data smoothing,³⁶ regression techniques using area-specific data as predictors,³⁵ and an array of Bayesian techniques.³⁷

Long used to estimate the prevalence of health-related behaviors at the U.S. county level,^{38–40} SAE methods have recently been used to estimate life expectancy of residents of U.S. census tracts (a within-city unit).⁴¹ Results suggest there is considerable variation in life expectancy between census tracts, underscoring that health varies within cities.⁴² CDC PLACES is another large-scale application of SAE methods in the U.S. context, estimating various chronic-disease-related measures at the sub-county level.⁴³ An advantage of SAE methods is that they borrow information from the higher level, allowing investigations of small areas (such as an urban neighborhood) to use fewer resources than they might require if the higher-level information were not available. As with most any method, estimation relies on assumptions, for example, that the association between demographics and the outcome at the larger area holds at the smaller area. In the urban-health context, SAE methods may face particular challenges for key populations such as migrants or those who live in slums, groups whose health is difficult to measure.^{44,45} A small-area estimate aiming to estimate the health distribution of refugee settlements may be uninformative, for example, if it uses as key inputs the health distribution of surrounding areas, which may not be a strong predictor of the health of a group of individuals who recently arrived to that area. Finally, caution is recommended when using small-area estimation to monitor changes over time,⁴³ as the methods may involve inputs with a coarse temporal resolution and because the model inputs may assume time-invariant predictor-outcome associations.

2.2.2 Describing the health-relevant context of urban areas

Descriptive epidemiology conventionally measures health outcomes (such as cancer incidence and death) and individual-level risk factors (such as smoking and diet). As knowledge about the environmental impacts on health continues to grow, an increasingly important task for descriptive epidemiology, together with other disciplines, will be to better characterize the multi-level social and physical environments in urban areas that give rise to health.^{24,46} As an example addressing this need, a research coalition developed a dataset covering 371 cities in Latin America with various consistently defined indicators of the social environment across economic, social, housing, governmental, institutional, and organizational domains.⁴⁶ They noted several challenges in developing this dataset including variation in data availability, quality, and spatial and temporal resolution and extent.

The surveillance of physical environmental conditions relevant for health has advanced considerably as data have become available from remote sensing (i.e., satellite imagery),⁴⁷ street-level imagery (such as Google Street View),⁴⁸ and open-source mapping software (such as OpenStreetMap).⁴⁹ For example, remote sensing has been used to measure urban green space,⁵⁰ street-view imagery to assess walkability and disorder of neighborhoods,^{48,51} and OpenStreetMap to assess building quality and attributes of the roadway network.^{49,52,53} One large-scale effort using some of these tools (OpenStreetMap, notably) is the creation of a multi-city dataset of livability indicators across several Australian cities.^{54,55} This dataset of Australian cities is impressive for its rich information about the physical urban environment at high (within-city) spatial resolution and the comparability of its measures between cities, as constituent cities are each measured using the same methods.

As illustrated by the creation of such large-scale multi-city datasets of the built environment, modern sources of street-level imagery and mapping software have eased the objective and harmonious assessment of the physical environment at scale. Challenges remain with their completeness, accuracy,⁵³ and ongoing availability and legal use in urban health-related research.⁵⁶

Related to the need for a consistent dataset of indicators of the social and built environment across and within cities is the need to systematically inventory laws, policies, interventions, projects, and other actions that could affect these indicators. As Diez Roux writes, “Cities are acting,”² but, as a whole, the public health community lacks a robust system for collecting data on these actions. The field of policy surveillance is seeking to address this need.⁵⁷ Stemming from the tradition of public-health surveillance, policy surveillance is “the systematic tracking of policies of public importance”, as defined in Chapter 14 of the *Urban Public Health* text.⁵⁸ Well-executed, policy surveillance provides accessible quantitative data over place and time on attributes of policies relevant for public health. This information can be used to monitor trends in policies known to affect public health and to evaluate population-health impacts of policies.^{57,58} Noteworthy policy-surveillance resources relevant for urban health in the U.S. context include LawAtlas.org⁵⁹ and CityHealth.org,⁶⁰ projects maintained by the Temple University Center for Public Health Law Research Policy Surveillance Program and collaborating organizations. In addition to the examples mentioned in Chapter 14,⁵⁸ the CDC’s Community-Based Survey of Supports for Healthy Eating and Active Living has conducted nationally representative policy surveillance of municipalities on topics such as physical activity⁶¹ and traffic safety.⁶² At the global level, the C40 Cities, a network of cities focused on climate-change action, have documented actions cities are implementing to adapt to climate change,⁶³ many of which likely have population-health co-benefits.⁶⁴

These resources provide a good foundation for urban-health policy surveillance. As compared with national or state-level policies, local-level policies are often more difficult to track systematically (owing to the complex layers of governance in municipalities, inconsistency across cities in maintenance of websites and public-facing documents, and the sheer number of municipalities as compared with other administrative units), and gathering historical policy-related information can be even more challenging.

Beyond the surveillance of codified policy, challenges are perhaps even more formidable in tracking sub-city actions that might not be viewed as policy per se but could nevertheless affect public health. Examples include the conversion of a vacant lot to housing, the construction of a neighborhood greenway, or the closing of a coal power plant. Epidemiologists, with expertise in measurement across various scales of time and place, data-management skills, and a high value placed on methodological rigor, are well-suited to contribute to the surveillance of policies, interventions, and other population-level actions that could affect public health. The field of legal epidemiology provides a direct avenue for epidemiologists to collaborate with lawyers and other policy experts to contribute to policy surveillance, specifically.⁶⁵ And existing global collaborations between urban planners, data scientists, and public-health professionals provides guiding examples of tracking other sub-city interventions.^{49,55} Critical data include where and when the action occurred, the geographic scale of the action, and, as applicable, the level of governance responsible.⁶⁶ For evaluation purposes, documenting when the intervention occurred is especially important so that methods considering intervention timing (described in the next section) can be applied.

2.3 Urban determinants and modifiers of health

As well as a context in which population health manifests, cities and their characteristics are determinants and modifiers of health.^{5,22,67} The magnitude of ill health arising from urban determinants—or the potential health benefits from urban interventions—can be used to inform action that decision makers can take. Understanding how impacts vary by place, time, or other contextual factors can inform whether and how to tailor action to specific urban contexts. While there is a long tradition of theoretical and empirical research studying determinants of health at levels above the individual (such as the neighborhood, city, or institution),^{68–70} research is less robust on the effects of specific actions and policies taken by governments and other actors on health and health equity. Methods to study the longitudinal effects of group-level

interventions, such as difference-in-differences, interrupted time series, and synthetic control methods,^{71,72} are well-suited for this purpose and have been used in recent years to study effects of policies and other actions between and within cities. When possible, these methods can take advantage of natural or quasi experiments.⁷³ Some examples of their use in the urban-health context include an assessment of the effects of keeping indoor restaurant dining closed on COVID-19 rates in large U.S. cities,⁷⁴ of a street-design intervention on pedestrian crashes in Mexico City,⁷⁵ of bicycling infrastructure on bicycling levels in Atlanta, United States,⁷⁶ and of a heat action plan on heat-related mortality in Montreal, Canada.⁷⁷ Some of these tools allow for the estimation of place-specific effects which can inform the extent to which intervention effects are modified by social or environmental context.⁷⁸ Understanding within-city effect modification can help to monitor impacts of city-level actions on disparities.

While these methods hold promise, they also bring about challenges for use in the urban-health context. One is that urban policies often co-occur,^{79,80} posing analytical challenges for isolating the impact of one specific action from another. Second, sometimes the area of interest has no suitable comparator over relevant characteristics, even when the comparator is a weighted average of several areas.⁸¹ This issue, sometimes called “non-positivity”, could arise in particular in unequal or segregated cities. A third is difficulty characterizing where to “draw the line” particularly for actions or events whose effects may be diffuse, such as wildfires or built-environment interventions.^{76,82,83} Fourth, as emphasized in [Section 2.2](#), longitudinally measured data on both the intervention and outcome are often not available, underscoring the need for sound surveillance. Fifth, quasi-experimental methods do not necessarily alleviate long-recognized concerns regarding the interpretation of group-level associations to individuals.⁸⁴ The ecological fallacy can occur when associations observed at the group level are assumed to hold at the individual level. More technically, it can occur when the joint distribution of the exposure and outcome is not available at the individual level, and group-level summaries are used as proxies for this individual-level distribution. Clarifying the target level of inference—individuals vs population distributions—remains important when using these quasi-experimental methods. While these challenges warrant further attention, this family of methods is sufficiently well-developed to be useful in a range of urban settings for the evaluation of policies, actions, and climate-related events.⁸²

2.4 Urban health as part of a complex systems

Above, we noted that a challenge with some policy-evaluation methods is isolating specific effects in the context of other co-occurring interventions and actions.⁷⁹ Perhaps more importantly, isolating specific effects may not always be the most useful question to answer if the goal is to improve population health.⁸⁵ These conceptual and methodological challenges motivate calls to view urban interventions and actions as part of complex systems.^{28,85–87} Features of complex systems include multiple levels of organization, heterogeneous units, dependencies between units, and feedback loops.²⁵ In the context of urban health, a complex systems approach recognizes the intricate interplay between human health, animal health, and the health of the environment. This perspective acknowledges that human health is not isolated but rather embedded within a broader ecological context. Specific conceptual frameworks that make this interconnectedness explicit include the One Health and planetary health.^{29,88} For example, seen through a planetary-health prism, urban green spaces not only provide recreational opportunities and promote physical activity, but also contribute to biodiversity, air quality, and climate regulation, benefiting both human, animal health, and mitigation of adaptation to climate change.

In a review of public health interventions adopting a complex-systems perspective, authors categorized the goals of such studies into five stages: theorizing, prediction, process evaluation, impact evaluation, and further prediction.⁸⁹ Information derived from considering urban health as a complex system adds a new layer of value for policy-making beyond the burden of urban ill health and the health impacts of specific urban determinants and actions. Well-executed, a complex-systems approach can help policymakers understand tradeoffs, unanticipated effects, implementation challenges, the potential impact of multiple interventions, and other effects arising from urban complexity.

While traditional statistical methods, such as linear regression, can be useful for analyzing certain aspects of urban health, they may be limited for capturing the complexity of these systems. Alternative modeling approaches, such as system dynamics models or agent-based models (ABMs), may be more suitable for simulating and understanding the dynamic behavior of urban health systems. Prediction (or simulation) is a common goal of these complex-systems methods, the purpose of which is to “hypothesize and simulate how an intervention may impact on and interact with a complex system” or, similarly, to “hypothesize and simulate how agents within a complex system react and interact in response to an intervention.”⁸⁹ Respectively, these two objectives roughly correspond to the approach of system dynamic models and ABMs.⁸⁹ The strengths of these systems methods are that they allow the investigator to perform complex simulations of how an intervention may unfold, considering interactions, interdependencies, and feedback.

ABMs, in particular, have been explored for their potential to inform and evaluate interventions related to urban health.⁹⁰ Authors exploring their utility and challenges have suggested that ABMs are attractive for three reasons. First, the method

“... is well-suited for modeling exposure influenced by specific behaviors, their timing, and location.”⁹⁰ Second, “any mathematical relationship— ... non-linear, complex interactions—can be algorithmically modeled in an ABM.”⁹⁰ Third, “ABMs can integrate many factors resulting in a holistic and context-dependent model.”⁹⁰ ABMs also raise several challenges, however.^{89–91} One is that they require a rich evidence base to inform their models. Evidence does not always exist to inform the various steps of such models, requiring researchers to rely on strong assumptions, and erroneous assumptions may affect model behavior in complex ways. Existing epidemiological evidence may also have been conducted in populations whose distribution of key characteristics differs from that in which the model is to be applied. These challenges imply that it remains important to conduct traditional epidemiologic research to inform these systems models.

3. Conclusions

3.1 Summary of needed understanding

The reviewed conceptual model considers various ways to understand—and even define—urban health. Within each conceptual frame, more work is needed to advance understanding of urban health and support action to improve the health of urban populations. For example, it is unknown how much ill health occurs in urban populations. In this article, we crudely estimated that about 30–35 million deaths occur annually in urban areas, but this estimate relies on strong assumptions and ought to be improved upon. More descriptive epidemiology is needed to characterize urban health with both fine (within-city) resolution and at a large (global) scale to better understand differences in health between and within urban areas. There is a need for improved measurements of both the health of urban populations and of the environments that give rise to health. Creating databases at the multi-city scale containing high-resolution indicators of the social and built environments and related policies, interventions, and other actions should be encouraged. Noted examples characterizing indicators and policies in Latin America⁴⁶ and Australia⁵⁵ may serve as a guide.

There is also a need to understand what works to improve urban health. Decades of research have shown links between social and physical urban environments and health, but research evaluating the impacts of actual actions (e.g., policies and interventions) that may affect urban health and health equity remains comparatively scarce. Monitoring actions between and within cities would enable such evaluations. Finally, the argument for considering the health effects of urban living as part of a complex system is persuasive,⁸⁵ but our tools for quantitatively understanding these system-level processes remain under-developed in the public-health literature, in particular for the evaluation of urban-health interventions.⁸⁹ That many of these systems modeling methods require information-rich empirical evidence also underscores the need for traditional epidemiologic research to inform their components. While it will take a multi-disciplinary effort to address these gaps in understanding, the discipline of epidemiology, specifically, can inform urban-health understanding by adopting a broad view of descriptive epidemiology that includes surveillance of the urban physical and policy environments, continuing to evaluate group-level interventions between and within urban areas, and advancing research on systems thinking in urban health issues.

3.2 Actions needed to support gaps in understanding

To support this needed understanding, we recommend several actions that can be taken by stakeholders in national governments, local governments, not-for-profit organizations, coalitions, and academia. National governments could increase funding for fine-scale urban health surveys and surveillance systems and develop dashboards displaying resulting measures. U.S.-based examples of such tools include New York University’s City Health Dashboard^{92,93} and the University of Wisconsin’s County Health Rankings.⁹⁴ As individual countries improve urban-health surveillance, the magnitude of urban-health challenges at the global or regional scale may become more apparent. Public health practitioners and other officials in local governments could similarly collect small-area health data and, ideally, present it in standardized formats on open-data portals.⁹³ Local governments are especially well-suited to conduct policy surveillance on actions that could affect urban health, as they are often responsible for their on-the-ground implementation. If data collection on all relevant interventions and actions is not feasible for government officials, they could partner with academic researchers, not-for-profit organizations, or global coalitions such as C40.⁹⁵ The evaluation of policies and interventions that could affect urban health at the local level is another area well-served by cross-sectoral collaboration. This collaborative evaluation research is particularly important in sectors not traditionally viewed under the public-health umbrella ranging from but not limited to transportation systems, housing policy, taxation policy, and energy systems. Throughout urban health surveillance and evaluation, care should be taken to collect data to represent marginalized groups and evaluate impacts on equity-related outcomes.

Data availability statement

No data are associated with this article.

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Version 2

Reviewer Report 18 March 2025

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Alina Schnake-Mahl

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The authors have addressed all comments. I appreciate their thorough responses.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: social epidemiology, policy evaluation, urban health, health disparities

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 04 December 2024

<https://doi.org/10.5256/f1000research.170075.r337107>

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Simon Rüegg 

University of Zurich, Zurich, Switzerland

Given that in the 21st century most of the global population is living in urban settings, the reflection on the importance and requirements of urban epidemiology are pertinent and timely. Particularly the geographic resolution is a hindrance in open sight which must be brought to the

attention of policy makers and health agents. However, given the current polycrisis including climate change, biodiversity loss and pollution which are directly and indirectly affecting human health, the sole emphasis on human health indicators seems somewhat anachronistic and narrowly focused. The authors legitimately build on historic practices in epidemiology using the four framings of cities as contexts, as determinants, as causes of human health and as complex systems that shape health.

I would find it interesting to differentiate somewhat more explicitly, which framing is useful for which kind of questions. Admittedly I am biased by a complexity approach to health. But I would advocate such an approach primarily for wicked health problems for which multiple aspects interact. Also, in the context of sustainable development participatory and complexity-aware approaches have shown to be more effective than linear analysis and intervention. There may however be public health related questions, e.g. health care infrastructure planning, which would benefit from a leaner and more data driven approach. I would welcome if the authors could include a reflection on the utility of framings in urban health decision making. Particular attention should be given to the ecological fallacy as populations are studied but individuals may participate in many populations and thus cumulate exposures or compensate them. This seems particularly tricky if geographical approaches are used that do not include behavioural parameters.

Many statements throughout the text and particularly section 2.4 seem to indicate that the authors acknowledge that cities are complex adaptive systems. This would imply that linear regression models and alike are tools that struggle to provide adequate information for decision making. This brings me to my main point of critique of the text in which I think, the field of medical epidemiology is well explored but expertise from ecology including its methods for analysis and modelling of complex ecosystems is largely missing. Secondly, in view of the polycrisis I would find it appropriate that urban health be concerned with other species than humans too, i.e. domestic animals, urban wildlife and plants, which in co-evolution and co-habitation with humans play a role in physical and mental human health but would also deserve some attention for their own sake. Understanding humans as part of nature and thus cities as dense ecosystems may shed some new understanding on public health issues, where species can co-benefit or co-suffer from exposures.

A further point that may be explored is that surveillance should be retrofitted from the decision making process to provide the data that is needed to make informed decisions. Traditionally, we use available data to produce information. However, when complex systems are addressed, it becomes more important to identify and collect the data that is needed to observe and monitor health over time. Particularly, when health is co-constructed with citizens, it will require more and more varied data than the one we are used to collect in medical and health communities, which still rely largely on a deficit-oriented definition of health, i.e. absence of disease.

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Is the topic of the review discussed comprehensively in the context of the current literature?

Partly

Are all factual statements correct and adequately supported by citations?

Yes

Is the review written in accessible language?

Yes

Are the conclusions drawn appropriate in the context of the current research literature?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Veterinary Epidemiology, Participatory Modelling, One Health, Knowledge Integration

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 28 Feb 2025

Michael Garber

Reviewer 3 (Simon Rüegg)

Reviewers comments

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Authors Response: We appreciate the reviewer's insightful comments and agree that a more integrated approach to urban health, encompassing human, animal, and environmental health, is crucial in the 21st century. We acknowledge that our current focus is primarily on human health, reflecting the traditional scope of epidemiology. Like Dr. Rüegg, we are interested in expanding this scope to better reflect the interconnectedness of human, animal, and environmental health, in line with the concepts of planetary health and One Health.

To address Dr. Rüegg's concerns, we have made the following additions to the manuscript:

1. **Explicitly differentiate the utility of each framing (cities as contexts, determinants, causes, and complex systems) for different types of urban health questions.** This will clarify the specific applications of each perspective and guide researchers and policymakers in selecting the most appropriate approach for their needs.

Added text: We added the following text to Section 2.1:

Measuring the magnitude of urban-health challenges through each of these lenses has value for researchers, policymakers, and advocates. For instance, viewing urban areas as *contexts* for health allows us to describe and compare health outcomes across different urban environments, highlighting disparities and identifying areas to prioritize for intervention. Understanding urban areas as *determinants* and *modifiers* of health enables us to investigate the causal impacts of specific urban characteristics and interventions on health outcomes and to inform action to change those characteristics. Finally, adopting a *complex systems* perspective allows us to appreciate the interconnectedness of factors influencing urban health, informing the development of holistic interventions at the structural level that can be mutually beneficial for many domains of population health, ecosystems, and climate resilience.¹

1. **Expand the discussion on complex systems to include the interconnectedness of human, animal, and environmental health.** This will acknowledge the broader ecological context of urban health and highlight the importance of considering these interrelationships when developing interventions and policies.

Added text: We added the following text at the end of the first paragraph of Section 2.4:

In the context of urban health, a complex systems approach recognizes the intricate interplay between human health, animal health, and the health of the environment. This perspective acknowledges that human health is not isolated but rather embedded within a broader ecological context. Specific conceptual frameworks that make this interconnectedness explicit include the One Health and planetary health.^{1,2} For example, seen through a planetary-health prism, urban green spaces not only provide recreational opportunities and promote physical activity, but also contribute to biodiversity, air quality, and climate regulation, benefiting both human, animal health, and mitigation of adaptation to climate change.

1. **Include a brief discussion of the ecological fallacy and its potential implications for urban health research.** This will emphasize the need for careful interpretation of group-level data and caution against making inferences about individuals based on aggregate-level observations.

Added text: We added the following text to Section 2.3 when discussing limitations and cautions of quasi-experimental methods:

Fifth, quasi-experimental methods do not necessarily alleviate long-recognized concerns regarding the interpretation of group-level associations to individuals.³ The ecological fallacy can occur when associations observed at the group level are assumed to hold at the individual level. More technically, it can occur when the joint distribution of the exposure and outcome is not available at the individual level, and group-level summaries are used as proxies for this individual-level distribution. The target level of inference—individuals vs population distributions—remains important when using these quasi-experimental methods.

1. **Acknowledge the limitations of linear regression models for analyzing complex systems and suggest alternative modeling approaches.** This will encourage the exploration of more sophisticated methods that can better capture the dynamic interactions and feedback loops inherent in urban health systems.

Added text: We added the following text at the beginning of the third paragraph of Section

2.4:

While traditional statistical methods, such as linear regression, can be useful for analyzing certain aspects of urban health, they may be limited for capturing the complexity of these systems. Alternative modeling approaches, such as system dynamics models or agent-based models (ABMs), may be more suitable for simulating and understanding the dynamic behavior of urban health systems.

Summary notes:

With these additions, we believe our manuscript is strengthened and better reflects the complex and interconnected nature of urban health in the 21st century.

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Kindly note that the reference order differs from that of the article.

1. Whitmee S, Haines A, Beyrer C, et al. Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. *The Lancet*. 2015;386(10007):1973-2028. doi:10.1016/S0140-6736(15)60901-1
2. De Castañeda RR, Villers J, Guzmán CAF, et al. One Health and planetary health research: leveraging differences to grow together. *The Lancet Planetary Health*. 2023;7(2):e109-e111. doi:10.1016/S2542-5196(23)00002-5
3. Wakefield J. Ecologic Studies Revisited. *Annu Rev Public Health*. 2008;29(1):75-90. doi:10.1146/annurev.publhealth.29.020907.090821

Competing Interests: None

Reviewer Report 21 November 2024

<https://doi.org/10.5256/f1000research.170075.r337108>

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Gregory Heath

Department of Health and Human Performance, Graduate Program in Public Health, The University of Tennessee at Chattanooga and the University of Tennessee Health Science Center College of Medicine Chattanooga, Chattanooga, Tennessee, USA

The authors provide a good overview of the position that urban health is critical to global health particularly relative to emerging economies among low to middle income countries, where there is a significant shift in populations moving from rural to urban centers.

This is compounded by the existence of what is referred to as the epidemiologic transition from

primarily infectious disease to non-communicable diseases (NCD) such as cardiovascular disease, T2DM, HTN, and their associated risk factors of obesity, physical inactivity, and unhealthy refined dietaries.

The authors appropriately identify the importance of descriptive epidemiology and public health surveillance to understand these population dynamics. Their emphasis on using such surveillance to track not only diseases and their biological risk factors but also policies and practices supporting environmental supports for healthy living within the context of the urban environment are key to protecting and promoting the health of urban populations. The paucity of such policy and practice surveillance is mentioned as a current deficiency within urban environments. Hence, the authors provide insights and a sense of urgency for the greater adoption of systems thinking in tackling urban population health, where intersectoral collaboration, coordination, and cooperation are currently often lacking both in intention and function.

The authors should cite additional sources of local health and policy data from the following sources:

The CDC Places data - that provides small area epidemiologic surveillance across sectors:
<https://www.cdc.gov/places/index.html>

Also, the County Health Rankings published by the University of Wisconsin's Population Health Institute should also be cited: <https://www.countyhealthrankings.org/>

References

1. Giles-Corti B, Moudon AV, Lowe M, Adlakha D, et al.: Creating healthy and sustainable cities: what gets measured, gets done. *Lancet Glob Health*. 2022; **10** (6): e782-e785 [PubMed Abstract](#) | [Publisher Full Text](#)
2. Giles-Corti B, Lowe M, Arundel J: Achieving the SDGs: Evaluating indicators to be used to benchmark and monitor progress towards creating healthy and sustainable cities. *Health Policy*. 2020; **124** (6): 581-590 [PubMed Abstract](#) | [Publisher Full Text](#)
3. Ramirez-Rubio O, Daher C, Fanjul G, Gascon M, et al.: Urban health: an example of a "health in all policies" approach in the context of SDGs implementation. *Global Health*. 2019; **15** (1): 87 [PubMed Abstract](#) | [Publisher Full Text](#)
4. Jacob V, Reynolds JA, Chattopadhyay SK, Hopkins DP, et al.: Parks, Trails, and Greenways for Physical Activity: A Community Guide Systematic Economic Review. *Am J Prev Med*. 2024; **66** (6): 1089-1099 [PubMed Abstract](#) | [Publisher Full Text](#)
5. Hunter RF, Cleland C, Cleary A, Droomers M, et al.: Environmental, health, wellbeing, social and equity effects of urban green space interventions: A meta-narrative evidence synthesis. *Environ Int*. 2019; **130**: 104923 [PubMed Abstract](#) | [Publisher Full Text](#)
6. Watkins DA: Intersectoral Policy Priorities for Health. 2017.

Is the topic of the review discussed comprehensively in the context of the current literature?

Yes

Are all factual statements correct and adequately supported by citations?

Yes

Is the review written in accessible language?

Yes

Are the conclusions drawn appropriate in the context of the current research literature?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Guerry Professor Emeritus in the Public Health and Medicine at the University of Tennessee Chattanooga and a former Lead Health Scientist/epidemiologist at the U.S. Centers for Disease Control and Prevention (CDC), for over 20 years. A doctorate in physiology/nutrition and an MPH in epidemiology from the Loma Linda University School of Public Health. I have spent most of my career devoted to the epidemiology, prevention, and management of chronic diseases and their associated behavioral risk factors (e.g., physical inactivity, poor diet, obesity). I am widely published in the preventive medicine and public health literature with an h-index of 65. I am a Fellow in the American College of Sports Medicine (ACSM) and the American Heart Association's Council on Epidemiology and Prevention.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 28 Feb 2025

Michael Garber

Reviewer 2 (Gregory Heath)

R2. Overview. The authors provide a good overview of the position that urban health is critical to global health particularly relative to emerging economies among low to middle income countries, where there is a significant shift in populations moving from rural to urban centers.

This is compounded by the existence of what is referred to as the epidemiologic transition from primarily infectious disease to non-communicable diseases (NCD) such as cardiovascular disease, T2DM, HTN, and their associated risk factors of obesity, physical inactivity, and unhealthy refined dietaries.

The authors appropriately identify the importance of descriptive epidemiology and public health surveillance to understand these population dynamics. Their emphasis on using such surveillance to track not only diseases and their biological risk factors but also policies and practices supporting environmental supports for healthy living within the context of the urban environment are key to protecting and promoting the health of urban populations. The paucity of such policy and practice surveillance is mentioned as a current deficiency within urban environments. Hence, the authors provide insights and a sense of urgency for the greater adoption of systems thinking in tackling urban population health, where

intersectoral collaboration, coordination, and cooperation are currently often lacking both in intention and function.

R2. Overview. Response: We appreciate Dr. Heath's thoughtful summary of our paper and his suggestions to include the additional citations for sources of local health and policy data.

R2.1. The authors should cite additional sources of local health and policy data from the following sources:

The CDC Places data - that provides small area epidemiologic surveillance across sectors:
<https://www.cdc.gov/places/index.html>

Also, the County Health Rankings published by the University of Wisconsin's Population Health Institute should also be cited: <https://www.countyhealthrankings.org/>

R2.1. Response: We appreciate the suggestion to add these resources. We've added a reference to CDC PLACES in the section on small-area estimation:

Quote from text: CDC PLACES is another large-scale application of SAE methods in the U.S. context, estimating various chronic-disease-related measures at the sub-county level.¹

R2.1. Response, continued: And we've added a reference to the U Wisconsin resource in the "Actions needed" section, by revising the following sentence:

Quote from text: U.S.-based examples of such tools include New York University's City Health Dashboard,^{2,3} and the University of Wisconsin's County Health Rankings.⁴

References

1. Giles-Corti B, Moudon AV, Lowe M, Adlakha D, et al.: Creating healthy and sustainable cities: what gets measured, gets done. *Lancet Glob Health*. 2022; **10**(6): e782-e785 [PubMed Abstract](#) | [Publisher Full Text](#)
2. Giles-Corti B, Lowe M, Arundel J: Achieving the SDGs: Evaluating indicators to be used to benchmark and monitor progress towards creating healthy and sustainable cities. *Health Policy*. 2020; **124** (6): 581-590 [PubMed Abstract](#) | [Publisher Full Text](#)
3. Ramirez-Rubio O, Daher C, Fanjul G, Gascon M, et al.: Urban health: an example of a "health in all policies" approach in the context of SDGs implementation. *Global Health*. 2019; **15**(1): 87 [PubMed Abstract](#) | [Publisher Full Text](#)
4. Jacob V, Reynolds JA, Chattopadhyay SK, Hopkins DP, et al.: Parks, Trails, and Greenways for Physical Activity: A Community Guide Systematic Economic Review. *Am J Prev Med*. 2024; **66** (6): 1089-1099 [PubMed Abstract](#) | [Publisher Full Text](#)
5. Hunter RF, Cleland C, Cleary A, Droomers M, et al.: Environmental, health, wellbeing, social and equity effects of urban green space interventions: A meta-narrative evidence synthesis. *Environ Int*. 2019; **130**: 104923 [PubMed Abstract](#) | [Publisher Full Text](#)
6. Watkins DA: Intersectoral Policy Priorities for Health. 2017.

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Kindly note that the reference order differs from that of the article.

1. Greenlund KJ, Lu H, Wang Y, et al. PLACES: Local Data for Better Health. *Prev Chronic Dis*. 2022;19:210459. doi:10.5888/pcd19.210459
2. City Health DASHBOARD. Accessed May 13, 2024. <https://www.cityhealthdashboard.com>
3. Thorpe LE, Gourevitch MN. Data Dashboards for Advancing Health and Equity: Proving Their Promise? *Am J Public Health*. 2022;112(6):889-892. doi:10.2105/AJPH.2022.306847
4. 2024 National Findings Report *Creating Thriving Communities Through Civic Participation*. University of Wisconsin Public Health Institute School of Medicine and Public Health; 2024. Accessed January 30, 2025. <https://www.countyhealthrankings.org/findings-and-insights/2024-national-findings-report>

Competing Interests: None

Reviewer Report 08 October 2024

<https://doi.org/10.5256/f1000research.170075.r324311>

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**Alina Schnake-Mahl**

Urban Health Collaborative, Department of Health Management and Policy, Drexel Dornsife School of Public Health, Philadelphia, USA

This article provides a structured framework for thinking about epidemiology and urban health, and opportunities for future epidemiologic work in this area. I commend authors for taking on the difficult but important task of outlining the epi case for urban health. The article is well organized, comprehensive, and provides a nice overview of current work. My suggestions are mostly small additions.

Cities and urban are used interchangeably- while other work such as the urban health textbook, have I believe worked to define these terms, it would be helpful to repeat or summarize the definition of urban and city for readers.

The sentence " Variable exposure to environmental conditions (both social and physical) gives rise to health inequities in urban populations by characteristics such as income and wealth, residential neighborhood, race and ethnicity, age, disability, gender identity, sexual orientation, or migration

status.¹⁶ “ seems to orient around individual level predictors of health inequities, rather than inequitable social, political, and environmental exposures as predictors of inequities. Both should probably be included.

Though the section on small area estimates is within the descriptive epidemiology section, it's important to add limitations of small area estimation for sub-unit evaluation of health changes over time, as the methods integrate sub-unit specific information and therefore shouldn't be used for assessing changes or evaluating local intervention effects over time, and any use with modeling should incorporate the uncertainty estimates. See, for example the language on the CDC PLACES website about limitations of using the data. It may be worth mentioning potential of Bayesian methods for small areas as well?

The section on tracking policy would benefit from acknowledging and briefly describing legal epidemiology and policy surveillance methods as burgeoning and rigorous methods to track laws and policies over time. However, local policies are often difficult to track especially historically, despite resources such as Municode, in the United States, because local laws and policies are often unavailable on city or county websites or tracking sources. This is also a good opportunity to highlight the importance of interdisciplinary collaborations (e.g. with lawyers or policy experts) to identify, code, and interpret laws and policies, while bringing our epidemiologic focus on sources of bias, good coding and data management practices, and fascination with methodological rigor.

- See for example (refer 1 and refer 2)

The paragraph on tracking policies would also benefit from citations focused on tracking city-level (or sub city-level) policies. Most of the citations are focused on state level (or multilevel – e.g. the matthay article) articles. Suggested citation:

- refer 3

It would be helpful to allude back to the issue of lack of outcome data at the city or sub-city level for quasi-experimental evaluation. It would also be helpful to mention the importance of understanding effect modification within a city (e.g. by neighborhood SES or SVI) to monitor impacts of city level policies on disparities.

References

1. Burris S, Lin V: Law and urban governance for health in times of rapid change. *Health Promot Int.* 2021; **36** (Supplement_1): i4-i12 [PubMed Abstract](#) | [Publisher Full Text](#)
2. Burris S, Hitchcock L, Ibrahim J, Penn M, et al.: Policy Surveillance: A Vital Public Health Practice Comes of Age. *J Health Polit Policy Law.* 2016; **41** (6): 1151-1173 [PubMed Abstract](#) | [Publisher Full Text](#)
3. Piekarz-Porter E, Oddo V, Stiehl E, Kim S: Beyond minimum wage: Broader employment policies can significantly affect food insecurity. *Translational Behavioral Medicine.* 2024; **14** (6): 333-337 [Publisher Full Text](#)

Is the topic of the review discussed comprehensively in the context of the current literature?

Yes

Are all factual statements correct and adequately supported by citations?

Yes

Is the review written in accessible language?

Yes

Are the conclusions drawn appropriate in the context of the current research literature?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: social epidemiology, policy evaluation, urban health, health disparities

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 28 Feb 2025

Michael Garber

Reviewer 1 (Alina Schnake-Mahl)

R1. Overview. This article provides a structured framework for thinking about epidemiology and urban health, and opportunities for future epidemiologic work in this area. I commend authors for taking on the difficult but important task of outlining the epi case for urban health. The article is well organized, comprehensive, and provides a nice overview of current work. My suggestions are mostly small additions.

R1. Overview. Response: We thank Dr. Schnake-Mahl for her kind comments and for her helpful feedback on our article. We made several changes in response to her feedback, as detailed point by point below. We believe our article has improved as a result of these changes.

R1.1. Cities and urban are used interchangeably- while other work such as the urban health textbook, have I believe worked to define these terms, it would be helpful to repeat or summarize the definition of urban and city for readers.

R1.1. Response: We agree that it would be helpful to discuss these terms more explicitly. We added a few sentences on this in the introduction:

Quote from revised text: As a preliminary note on language, an *urban area* has been defined “as a geographical space characterized by a continuous urban settlement.”¹ The phrase is commonly used in a more general sense than *city*, which can refer to a discrete urban area defined with administrative boundaries.² For a rigorous discussion of these terms, we recommend Chapter 1 of Urban Public Health by Diez-Roux² and Tonne et al (2021).³ In this article, we usually use the more general term—*urban area*—but occasionally use the word *city* as a rhetorical shorthand.

R1.2. The sentence “ Variable exposure to environmental conditions (both social and physical) gives rise to health inequities in urban populations by characteristics such as income and wealth, residential neighborhood, race and ethnicity, age, disability, gender identity, sexual orientation, or migration status.¹⁶ ” seems to orient around individual level predictors of health inequities, rather than inequitable social, political, and environmental exposures as predictors of inequities. Both should probably be included.

R1.2. Response: We appreciate Dr. Schnake-Mahl raising that this sentence evoked this implication. It was not our intention to focus on individual-level characteristics as causes of inequities. We have slightly revised this sentence to more clearly assert that the causes of inequities tend to be structural (above-the-individual) factors:

Quote from revised text: “Unequal exposure over time to social, political, and environmental conditions gives rise to health inequities in urban populations by characteristics such as income and wealth...”

R1.3. Though the section on small area estimates is within the descriptive epidemiology section, it's important to add limitations of small area estimation for sub-unit evaluation of health changes over time, as the methods integrate sub-unit specific information and therefor shouldn't be used for assessing changes or evaluating local intervention effects over time, and any use with modeling should incorporate the uncertainty estimates. See, for example the language on the CDC PLACES website about limitations of using the data. It may be worth mentioning potential of Bayesian methods for small areas as well?

R1.3. Response: We thank Dr. Schnake-Mahl for suggesting that we add the caution of using SAE methods for assessing changes over time. Upon consulting CDC PLACES materials, as suggested, we've added the following sentence:

Quote from revised text: Finally, caution is recommended when using small-area estimation to monitor changes over time,⁴ as the methods may involve inputs with a coarse temporal resolution and because the model inputs may assume time-invariant predictor-outcome associations.

R1.3. Response, continued: We also agree with the suggestion to mention Bayesian methods. We've added a citation to an article that summarizes development in SAE and disease mapping through a Bayesian lens (bold denotes addition).

Quote from revised text with addition underlined: SAE methods include, for example, non-parametric methods that use measured associations between the outcome and demographic characteristics at the larger geographic unit (e.g., U.S. states) and apply those associations to smaller units where the outcome is not measured (such as counties), spatial data smoothing,⁵ regression techniques using area-specific data as predictors,⁶ **and an array of Bayesian techniques.**⁷

R1.4. The section on tracking policy would benefit from acknowledging and briefly describing legal epidemiology and policy surveillance methods as burgeoning and rigorous methods to track laws and policies over time. However, local policies are often difficult to track especially historically, despite resources such as Municode, in the United States, because local laws and policies are often unavailable on city or county websites or tracking sources. This is also a good opportunity to highlight the importance of interdisciplinary collaborations (e.g. with lawyers or policy experts) to identify, code, and interpret laws and policies, while bringing our epidemiologic focus on sources of bias, good coding and data management practices, and fascination with methodological rigor.

- See for example (refer 1 and refer 2)

R1.4. Response: We again thank Dr. Schnake-Mahl for the helpful suggestion, as we had limited familiarity with legal epidemiology and the resources she suggested. We read these suggested references and made major revisions to this part of the text. The paragraph beginning with “Related to the need for...” in Section 2.2.2 has been rewritten almost entirely guided by these suggestions.

R1.5. The paragraph on tracking policies would also benefit from citations focused on tracking city-level (or sub city-level) policies. Most of the citations are focused on state level (or multilevel – e.g. the matthay article) articles. Suggested citation:

- refer 3

R1.5. Response: Again, we appreciate Dr. Schnake-Mahl’s attention to this detail. In this section, we’ve omitted our citation to the Matthay article in this particular section—although we still cite it in discussing challenges of co-occurring policies. And we now include more examples of city-specific policy surveillance.

R1.6. It would be helpful to allude back to the issue of lack of outcome data at the city or sub-city level for quasi-experimental evaluation. It would also be helpful to mention the importance of understanding effect modification within a city (e.g. by neighborhood SES or SVI) to monitor impacts of city level policies on disparities.

R1.6. Response: On the first point, we agree. We’ve added the following sentence to Section 2.3 when discussing challenges with quasi-experimental methods

Quote from text: Fourth, as emphasized in Section 2.2., longitudinally measured data on both the intervention and outcome are often not available, underscoring the need for sound surveillance.

R1.6. Response: Regarding the second point (effect modification), we had noted the opportunity for assessment of effect modification, but we agree that this could have been emphasized more. We’ve added another sentence on the importance of effect modification

Quote from text (bold denotes addition): Some of these tools allow for the estimation of place-specific effects which can inform the extent to which intervention effects are modified **by social or environmental context.**⁸ **Understanding within-city effect**

modification can help to monitor impacts of city-level actions on disparities.

References

1. Burris S, Lin V: Law and urban governance for health in times of rapid change. *Health Promot Int.* 2021; **36**(Supplement_1): i4-i12 [PubMed Abstract](#) | [Publisher Full Text](#)
2. Burris S, Hitchcock L, Ibrahim J, Penn M, et al.: Policy Surveillance: A Vital Public Health Practice Comes of Age. *J Health Polit Policy Law.* 2016; **41** (6): 1151-1173 [PubMed Abstract](#) | [Publisher Full Text](#)
3. Piekarczy-Porter E, Oddo V, Stiehl E, Kim S: Beyond minimum wage: Broader employment policies can significantly affect food insecurity. *Translational Behavioral Medicine.* 2024; **14** (6): 333-337 [Publisher Full Text](#)

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Kindly note the reference order differs from that of the article.

1. Mela A. Urban Areas. In: *Encyclopedia of Quality of Life and Well-Being Research*. Springer, Dordrecht; 2014:6826-6828. doi:10.1007/978-94-007-0753-5_3122
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Competing Interests: None

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