Commentary

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Advancing research on greenspace and climate-sensitive adverse birth outcomes for equity and impact

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Abstract: Environmental epidemiologists are increasingly evaluating whether and how human exposure to vegetation (greenspace) can benefit health. Relatedly, scientists and policymakers have highlighted the need to integrate efforts to address the dual crises of accelerating climate change and rapid loss of biodiversity, including nature-based solutions. Greenspace is one solution that can protect humans from climate-related exposures, including heat, air pollution, and flooding. However, most environmental epidemiology research on greenspace occurs in high-income countries, and adverse birth outcomes, previously associated with greenspace, disproportionately occur in low- and middle-income countries (LMICs). Although epidemiology research using existing survey or administrative data and satellite imagery is important for documenting broad patterns, such research is lacking in LMICs. Further, complementary, community-engaged research to inform interventions and policies is needed so that nature-based solutions with co-benefits for climate mitigation and health are adopted effectively and equitably. We provide suggestions for future research that would increase impact and call for better representation of LMICs and vulnerable communities within high-income countries in research and action on greenspace and climate-sensitive birth outcomes.

Keywords: Greenspace; Climate change; Environmental exposure; Maternal exposure; Pregnancy outcomes; Equity

Climate change-related exposures, including extreme weather, wildfires, air pollution, changes in ecology, and floods, disproportionately affect the world's vulnerable populations, including pregnant persons and developing fetuses. Extreme heat and air pollution exposures have been associated with adverse pregnancy outcomes, including preterm birth (PTB), low birth weight (LBW, live birth with weight less than 2500 grams), and stillbirth.[1–3] PTB (live birth before 37 weeks of gestation) accounted for approximately 0.94 million deaths of children under 5 years of age in 2019 globally.[4] LBW is related to fetal and neonatal morbidity and mortality, inhibited growth and cognitive development, and noncommunicable diseases later in life.[5] Each year, 2 million stillbirths (fetal death after 28 weeks of gestation or at least 1000 grams at birth) occur worldwide.[6] Notably, most adverse birth outcomes occur in lower- to middle-income countries (LMICs). Over 80% of PTBs globally were from South Asia and sub-Saharan Africa in 2014.[7] Similarly, 91% of all LBW babies in 2015 and 83.6% of all stillbirths in 2019 were from LMICs.[8,9] The large proportion of adverse pregnancy outcomes occurring in LMICs may be due to limited health care access, poor or suboptimal nutrition, lack of education and resources dedicated to pregnancy health, and prenatal chemical exposures and stress.[10–12] The environmental consequences of climate change in LMICs are also adversely impacting pregnancy outcomes[13] and these risks may be amplified due to weak health infrastructure, inequitable distribution of resources, and lower socioeconomic status.[14]

Climate change-driven environmental phenomena such as heatwaves, air pollution, wildfires, and extreme weather have been associated with adverse pregnancy outcomes,[15–18] and some of these exposures affect people in both community and occupational settings. These adverse pregnancy outcomes are avoidable. For instance, heat impacts are preventable with evidence-based warning systems, heat advisories, and action plans to mitigate exposure, including workplace policies.[19] Focusing on how immediate environments may impact health can offer additional sustainable, health-promoting interventions. Accumulating evidence suggests that women living in areas where residential greenness is higher may experience improved pregnancy outcomes.[20] For example, greenspace was the most consistent of 24 urban environmental factors in its association with increased birthweight and decreased risk of term LBW.[21] Several studies observed an association between greenspace and decreased risk of PTB.[22–24] Others have reported interaction, mediation, or modification by air pollution of greenspace

What this study adds

We highlight in this commentary an important gap in epidemiology research on greenspace and climate-sensitive birth outcomes in lower resource settings of the world, where impacts can be greatest. We provide context on current discussions on nature-based solutions and challenges to interventions in these settings and recommend a range of study types that can fill knowledge gaps and lead to beneficial action.

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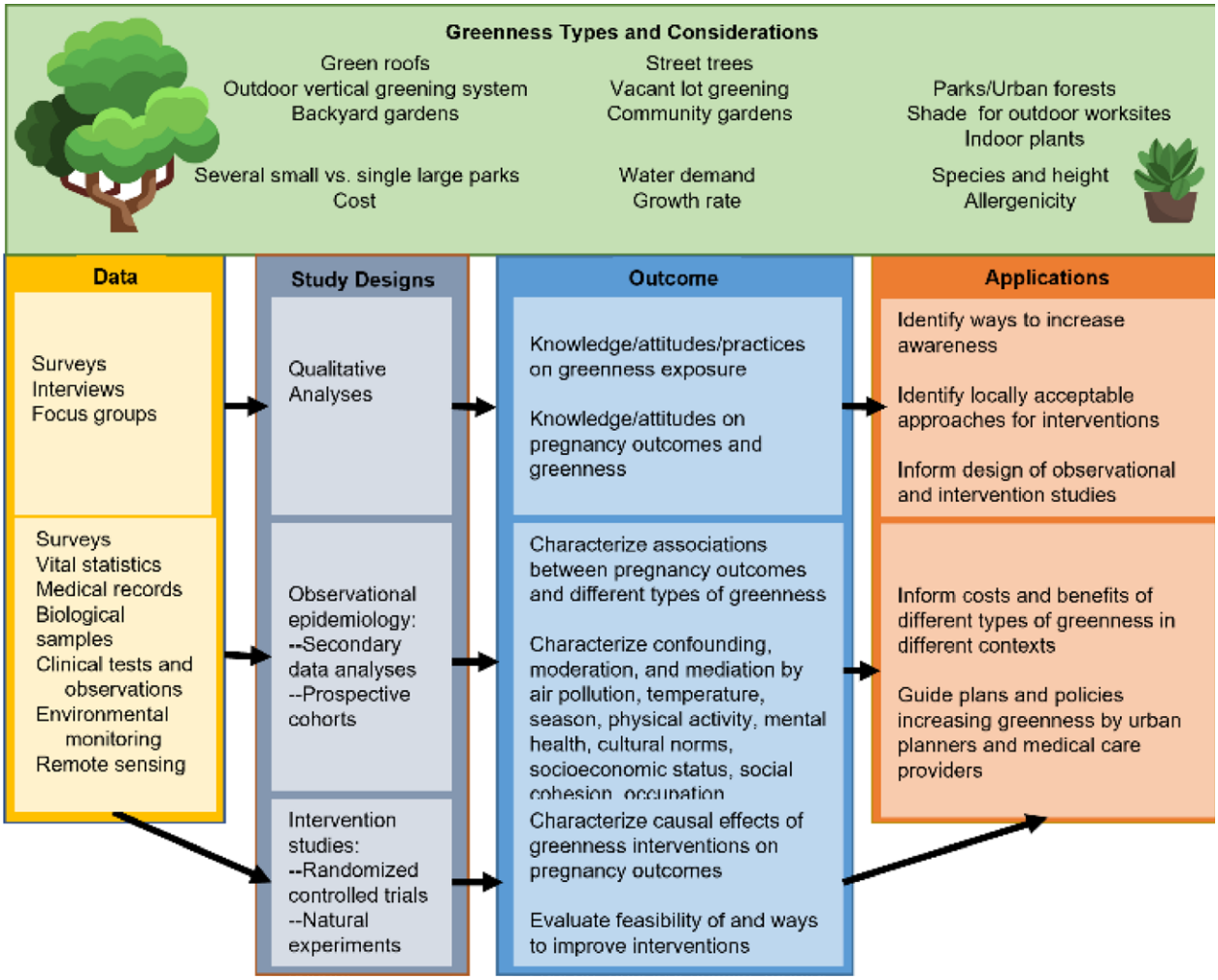

Figure. Recommendations and applications of studies of pregnancy outcomes and greenness in low-to-middle-income countries.

and birth outcome associations.[25,26] Little is known about how associations between surrounding greenness and adverse pregnancy outcomes vary according to the spatial configuration of vegetation (which can affect cooling potential[27]), types of vegetation, plant diversity, biodiversity, degree of heat attenuation by the vegetation, accessibility to greenspaces, and actual uses of green space (e.g., for physical activity). Furthermore, almost all previous studies have been conducted in high-income countries,[28] and results may not generalize to women in LMICs who are exposed to vastly different social, demographic, physical, and meteorological environments.[29] Also, greenspace exposure differs between Global South and North cities, with Global South cities experiencing only one-third of the greenspace exposure level of Global North cities.[30] The lack of environmental research capacity to obtain exposure data, the paucity of registry-based health data, and the competing need for resources to improve health conditions during pregnancy (e.g., enhancing nutrition and prenatal care) are important obstacles to studying this relationship in LMICs. Thus, a significant gap in the environmental epidemiology literature exists on the association between greenness and adverse pregnancy outcomes in LMICs, where high rates of adverse pregnancy outcomes and climate change-induced environmental consequences occur.

As part of integrated efforts with other health and socioeconomic interventions to reduce adverse pregnancy outcomes in LMICs, robust and cost-effective climate change mitigation and adaptation policies to build resilience are critical. Interest is increasing in using "nature-based" solutions,[31] to promote human well-being using approaches that restore "natural" ecosystem structure and/or function.[32] This increasing interest parallels the dialogue about how limiting future climate change and protecting biodiversity are congruent goals.[33] Greenness could be an effective nature-based solution, with the potential to minimize climate change impacts at a relatively low cost while delivering multiple benefits, including cooling effects, flood reduction, pollution and heat mitigation, retaining water in the soil, supporting biodiversity, and securing ecosystem services.[34] Yet, the potential of greenness to provide beneficial effects on multiple health outcomes,[35] including PTB, requires further assessment. Seddon and colleagues[36] describe challenges to the assessment of the benefits of nature-based solutions for slowing climate change and protecting humans from its adverse effects. They note challenges in measuring or predicting the effectiveness of nature-based solutions, in estimating their cost-effectiveness, and mention that engineered interventions are often the default, limiting the uptake of the green interventions. They call for a systems-thinking approach that includes multiple sectors and acknowledges trade-offs,[36] to encourage the integration of nature-based solutions in policy.

Epidemiological studies on greenness and pregnancy outcomes that identify the contextual social (e.g., social cohesion and cultural norms) and environmental mediating (e.g., heat, air pollution, psychosocial stress, physical activity, chemical exposures, occupational stress, and strain) or modifying factors (e.g., socioeconomic status, proximity to greenspace, and built environment features) in LMICs are necessary to advance knowledge

on the topic and guide interventions. LMICs may have more natural greenspace due to climate conditions and less intensive urban development compared with high-income countries, and correlations between greenspace and multiple other factors and potential nonlinear associations between greenspace and birth outcomes are key concerns. In the absence of registries, birth outcome data from surveys from LMICs can be used for studies.[37,38] Better representing the regions most adversely impacted will strengthen the scientific evidence base for greenness as a potential nature-based solution and help guide sustainable and contextual multi-level intervention initiatives. Of course, some settings have arid climates or other conditions that may not support green interventions. In conducive settings, choosing local and/or drought-resistant plantings and integrating initiatives within broader urban planning and development strategies is advisable.

Existing intervention studies on greenness and health are primarily focused on vacant lot conversion into greenspace or green prescription (e.g., horticulture therapy and forest therapy)[39] in high-income countries. Implementing green adaptation strategies in any region of the world should include community engagement, and LMICs are no exception to requiring public participation to raise awareness.[40] Additionally, engagement with local communities can identify locally acceptable approaches on implementing greenness. Finally, intervention studies are vital to identifying the best strategy to incorporate greenness into communities, and the types of greenness (species), location (e.g., rooftop, green wall, courtyard, vacant lot, and open spaces), route of exposure, and specific periods of exposure—most beneficial for pregnancy. Future studies should also consider the linkage between greenness and allergenicity as more greenery can lead to increases in airborne pollen, which can exacerbate allergy symptoms during pregnancy. Recommendations on studies needed in LMICs to fill these gaps in knowledge are presented in the Figure. Such studies, conducted in partnership with local researchers and communities to ensure information is tailored to the local context,[41] could yield vital information for researchers, urban planners, policymakers, and stakeholders on creating natural environments to combat climate change effects on adverse pregnancy outcomes in LMICs and worldwide.

Conflicts of interest statement

The authors declare that they have no conflicts of interest with regard to the content of this report.

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