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Urban health and planning in the 21st Century: Bridging across the formal and informal using an eco-social lens

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Urban health and planning in the 21st Century: Bridging across the formal and informal using an eco-social lens

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Editorial: Urban health and planning in the 21st Century: bridging across the formal and informal using an eco-social lens

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Editorial on the Research Topic
Urban health and planning in the 21st Century: bridging across the formal and informal using an eco-social lens

In today's rapidly urbanizing world, the issues surrounding the nature of urbanization, urban habitats and urban policies have become critical to ensure the collective health and wellbeing of people, animals, and the planet. Environmental degradation and climate change, emerging infectious diseases, rising non-communicable diseases at younger ages, increasing urban population density, and intensifying inequalities in access to healthcare, among others, pose serious challenges today, demanding a creative rethink of urban health and its determinants.

Urban health and wellbeing emerge from the dynamic relationship shared between urban dwellers and their living environments, shaped by their differential capabilities to meet habitat, healthcare and other needs in light of planned urban development. Urban living, involving health-related practices, livelihoods or quotidian amenities and routines, typically bridges the formal and informal divide present in policy. The complementarities and contradictions shaping the complexity of urban health need multimodal explorations into not just the urban health system but also urban design, planning and management for sustainable urbanization. The break in the relationship between public health and urban planning as twin approaches to address the same set of problems needs to be remedied.

In urban planning, there is increasing recognition of the value of understanding the "informal" as a ubiquitous presence that merits incorporation into formal planned interventions (1). In public health, however, this is not yet as pervasive an idea, despite the well studied presence of "the folk" in health-related practices, and even less so when thinking about urban health (2).

The studies included under this Research Topic bring attention to the phenomenon of the "informal" spanning a wide range of issues from examining determinants of

urban health for rural-to-urban migrants to indicating potential pathways that attempt to bridge across the formal and informal, to some methodological approaches for assessing such interventions. Zhao et al., for instance, interrogate how factors such as information transmission, health habits, social capital, and cultural identity, in addition to access to quality healthcare, shape the migrants' urban health-related experience and practice. The impacts of urbanization on health, however, can unfold in seemingly different ways as two studies in this collection found. Luo and Wang, analyzing a baseline survey of chronic diseases from 2011 to 2021 in southeastern China, observed a statistically significant relationship between urban living and the prevalence of type 2 diabetes, hyperlipidemia, and hypertension which, however, diminished with improvement in the healthcare system. Among the mediators, psychological distress had the highest positive coefficient for these diseases. Curiously, the study by Li et al., examining potential gender differences in the association of urbanization with psychological stress among Chinese adults, found that women in the most urbanized communities were likely to have lower levels of psychological stress than those in the low urbanized communities. Changing gender roles in the urban context, the authors explain, may have eased women out of stressful family environments while the crowded urban areas allowed greater access to modern markets, mental health professionals as well as neighborhood social support.

Social support in the urban context, especially for the underprivileged, often involves a complex interplay of different actors and networks. The absence of adequate and quality formal services in informal settlements is often filled by the urban poor through informal means in a show of resilience. That however cannot be an excuse for inaction by the formal system. The study by Chumo et al., conducted across two informal settlements in Nairobi, found that a complementary role of formal and informal actors including their respective networks is essential to supporting vulnerable populations. Chumo et al.'s other paper on Community Advisory Committees in informal settlements of Africa highlights the significance of social participatory mechanisms for advancing community health needs and priorities in an environment otherwise characterized by "a combination of patronage and neglect, insecurity and inequity."

Urbanization creates both opportunities and exclusions. Issues of equity critically determine the varied experiences across diverse urban populations (3). While there have been attempts at mapping urban inequities, whether in terms of socio-economic status or health-seeking, the study by Lowensen et al. examines the contribution of diverse health-promoting urban initiatives to different dimensions of health equity in East and Southern Africa. Most initiatives in low-income communities prioritized social determinants of health, such as water-sanitation-waste management, energy, land, biodiversity, urban agriculture and food security as precursors to urban health and wellbeing. Across these initiatives participation of different social groups and recognition of their differential needs was better represented than distributional, structural and intergenerational equity. Gao et al. also explored equity in access to public green spaces across American neighborhoods during the COVID-19 pandemic, finding that it worsened particularly for the marginalized groups.

While all these papers used innovative methods to study multi-dimensional issues in relation to urban living, two studies specifically examined methodological approaches. Eaton et al. developed a tool by using an environmental economics approach to estimate the health impacts of environmental change. Given the challenges involved in synthesizing a wide range of evidence for the exercise, the authors do however caution that expert interpretation and contextual understanding are critical. The other study by Nel et al. explicated the use of Broad Brush Surveys for a quick qualitative assessment of the formal-informal processes involved in water and sanitation services in the context of rapid urbanization. Both tools hold promise for assessing and estimating the impacts of urbanization.

We hope these papers will move the public health and urban planning discussions forward in recognizing the value of bridging the formal-informal dimensions of health and healthcare in developing urban systems with the goal of health for all being a central tenet. There are multiple global and regional policy-oriented networks including that of WHO and UNESCO that are involved in identifying good practices; promoting multi-stakeholder city-to-city learning exchanges as well as developing institutional and evidence-based policy frameworks for improved governance (4). We do hope that the significance of bridging the formal and informal will be of value to these processes as well.

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Dialect culture and the utilization of public health service by rural migrants: Insights from China

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The right to health is a fundamental human right for human beings to live in dignity. Everyone has the right to enjoy the fair and accessible highest standard of health by utilizing public health services. However, access to essential public health services also highly depends on the dialect culture. It is believed that the dialect culture also influences the efficiency of public health policies. To explore the phenomenon empirically, the current study utilized data sourced from geographical distribution information of Chinese dialects and the China Migrants Dynamic Survey for 2017. The study employed the Probit, IVprobit, and Eprobit models to estimate the impact of dialect culture on migrants' use of public health services. The findings revealed that the dialect culture significantly hinders the migrants' utilization of public health services. Further, by employing heterogeneity analysis, the findings revealed that the results are more pronounced in migrants, born after 1980, and are female with low educational background and also those migrants having local medical experiences and moving toward non-provincial cities. Finally to explore the mechanism of dialect culture influencing migrants' public health service, the study employed mediation analysis and KHB Method. The findings revealed that information transmission, health habits, social capital, and cultural identity are the potential pathways influencing the migrants' use of public health services. The findings conclude that rural-to-urban migrants' access to public health services is influenced by their cultural adaptation. Hence, the study proposes that the government should amend the policy inefficiency concerns caused by cultural differences and strengthen the regional cultural exchanges to build trust.

KEYWORDS

public health services, dialect culture, rural-to-urban migration, China, cultural barriers

Introduction

Health is an inclusive state of mental, physical, and social wellbeing. According to the Constitution of the World Health Organization (1), attaining the highest health standard is considered a fundamental human right for every individual. Health is human capital and is considered as durable as physical capital (2). But health depreciates with time; that can be maintained with improved health systems. Public health system also plays vital role in guarding against uncertain catastrophes such as COVID-19 pandemic. So providing equity in health care access is regarded as the main factor by Universal Declaration of Human Rights organization (3). There are many factors that lead to inequalities in availing health services utilization (4, 5). For instance, low income, poor living conditions, and reduced access to health services lead people to the worst health, especially impoverished populations who often access fewer health services despite higher demand. Moreover, in the context of rural-urban migration; various factors influence the health services of the migrant people. Migrant workers are less likely to establish health records, participate in health education programmes, and seek medical care. So the point of interest is how to expand the provision of health services for most rural populations. In this study, we emphasized China; China is the largest developing country, which witnesses millions of migrations of rural people annually from rural to urban areas. According to the "Statistical Bulletin of the People's Republic of China on National Economic and Social Development in 2021" (National Bureau of Statistics of China), the total number of rural migrants in China reached 292.51 million in 2021, which accounted for 20.71% of the country's total population. Moreover, it is also stated that comparatively, urban residents and rural migrants are more vulnerable to infectious diseases. Insufficient supply, accompanied by low service quality, makes migrants' health even worse. In this regard, the utilization of public health services by rural migrants is regarded as a crucial phenomenon to be explored. It is generally believed that rural migrants cannot enjoy the same public services and social benefits as registered inhabitants especially basic public health services (6, 7).

In 2009, China launched the National Health and Family Planning Commission and emphasized equalizing essential public health services for migrant people. Likewise, the 19th National Congress of the Communist Party of China also emphasized accelerating the equalization of essential public services. Further, the "14th Five-Year Plan for National Economic and Social Development of the People's Republic of China and the Outline of Vision 2035" in 2020 also aimed at strengthening the public health system. Due to continuous efforts, the health policies at the national level in China improved; per capita, the primary public health service funding standard in China rose from 17 yuan in 2009 to 79 yuan in 2021. The services also increased from the initial nine categories to 14 categories. Despite the positive repercussion, people's awareness and utilization of essential public health services are not improved, especially among rural migrants (8, 9). That led to the waste of medical and health resources and also influenced the supply of essential public health services effectiveness. The previous literature revealed that place of residence is associated with disparities in health services (10–12). Moreover, China is a multi-ethnic and multi-lingual country with a vast territory, a large population, and a long history. Different regions have formed rich and complex regional cultures. The cross-regional flow of rural migrants alters the cultural environment, influencing their utilization of public health services. In the healthcare sector, it is believed that culture and linguistic incompetence significantly influences healthcare delivery, healthcare consumption, and health outcomes (13). It is evident in various communities and a region, including China, that multilingualism (the presence of more than one language) adversely affects health (14). In this regard, Zhang et al. (15) proposed opting for interventions such as professional interpreter service, service-learning interpreter programs, or mobile interpreting apps that are medically accurate and culturally sensitive for dialectally diverse China.

In the prevailing literature, many researchers explored migrants' use of public health services by focusing on factors such as age, education level, marital status, family income, residence time, migration scope, social network, medical insurance, health status, and air pollution (16–20). However, regarding demanders for public health services, rural migrants are likely to have a relatively recessive factor derived from their characteristics, resulting in a shortage of public health services at the individual level. Moreover the dialect culture is also likely to influence the public health services primarily in the context of migrants, as patients with linguistic barriers are subject to unnecessary health services, undesirable outcomes, and excess healthcare costs (13). These communication barriers in healthcare institutions without formal language support may have an undesirable impact on healthcare delivery and the patient-healthcare provider relationship. So based on the above discussion, the current study aims to explore the influence of dialect culture on the utilization of public health services by rural migrants. The study further explores the mechanism between dialect culture and the utilization of public health services. As per the authors' knowledge, these notions remained under-researched in the existing literature generally and especially in the context of China.

The rest of this paper is structured as follows: the next section Literature review and hypothesis development reviews the literature on dialect culture and rural migrants' utilization of public health services and puts forward the research hypothesis. Section Methodology introduces the primary variables, data sources, and estimation strategies. The empirical results are presented in section Empirical results. Section Discussions discusses the main findings of this study and compares

them with existing research. In last, section Conclusion and policy implications concludes the study with several policy implications. The study limitations are also presented in this section.

Literature review and hypothesis development

This section attempts to sort out and review recent literature on the relationship between rural migrants' public health services utilization and language research. Firstly, the relevant research regarding the factors of the utilization of public health services for rural migrants is explored. Then the impact of language on the public health service of rural migrants is revealed. Based on the literature, the current study proposed the hypothesis and conceptualized the framework operationalized.

Concerning the utilization rate of public health services for rural migrants, the existing studies have explored the phenomenon based on three aspects: the formulation of public health service policies, the implementation of public health service policies, and the demanders themselves. From the formulation of public health service policies, public health service costs influence the rural migrants' public health services utilization and the population they cover. Some studies revealed that high cost increases treatment and prevention services utilization (21, 22). In contrast, some studies revealed that higher cost reduces public health service coverage (23–25). In the context of medical insurance, it is found that it can significantly improve the utilization of public health services for rural migrants (26, 27). The study by Hong et al. (28) and Chen et al. (29) revealed that the lack of medical insurance rights and interests of rural migrants often causes them to be unable to seek medical treatment due to illness, and minor illnesses lead them to significant distress and even lead them to lose their ability to work. From the perspective of implementing public health service policies, Li et al. (30), in his study, revealed that the government departments do not adequately publicize essential public health services, which leads to the lack of understanding of the policies by the rural migrants. As a result, public health services are not effectively utilized (31). The study of Suphanchaimat (32) found that interactions between healthcare providers and migrant patients also influence the migrants' public health services utilization. For individual factors, Chiu (33) argued that the prevalence of mental health factors and the use of mental health services vary widely across ethnic groups. Likewise, Celik (34), Ahmed (35), and Tzogiou (36) revealed that socioeconomic factors of migrants, such as occupational category, living conditions, and income status, also lead to the unequal utilization of public health services by migrants. Furthermore, social integration and discrimination also severely undermine the cross-border healthcare utilization among migrants of Russian descent (37). It is also believed that higher education levels are associated with higher levels of migrant acceptance of new medicines. Several studies affirmed that educational levels significantly increase women's utilization of public services (38–42).

Some studies also analyzed the impact of language on the utilization of public health services for rural migrants. The study of Peled (43) revealed that the globalization and normalization of population mobility have become increasingly prominent; as a result, the issue of crossing language barriers has brought significant challenges concerning the quality and equitable provision of health services. Likewise, Lara (44) revealed that migrants positively correlate the degree of cultural adaptation and utilization of medical resources. Communication barriers mainly cause the low utilization rate of medical resources. A recent study by Khatri and Assefa (45) also revealed that language and communication problems adversely influence people's access to public health services. Likewise, Wang et al. (46) also found that language and culture influence the public health services accessibility to older migrants in the case of Canadian migrant workers. Another study by Salami et al. (47) also exhibited the same findings and unveiled that language is the main barrier to accessing and utilizing mental health services by migrants. Compared with Canadian and American migrants in English, the utilization rate of limited English immigrant public health services is significantly higher (48). Rasi (49) also revealed that cultural and language differences unfavorably influence the communication between migrant patients and public health professionals, hindering the migrant patients' accessibility to health care services.

Based on the literature, it is found that only a handful of studies explored the relationship between language barriers and public health service utilization by international migrants. In the case of rural domestic migrants, the studies are also found scarce. The main difference between rural migrants and residents is that they were born and raised in different places. In a specific growth environment, rural migrants have long been deeply branded with the imprint of regional culture. Behind the transfer from rural to urban areas are cultural conflicts and adaption between different regions. Lu et al. (50) analyzed the impact of language barriers on the health status of the elderly migrants. They found that language barriers reduced the ability of the elderly migrants to build social networks, which led to poorer health status.

Further, as a typical informal system, regional culture has a subtle and profound impact on the cognition, interaction, and strategic choice of rural migrants in the process of using public health services. Many features may contribute to this phenomenon; firstly, having similar cultural backgrounds induces communication and coordination between two groups, while cultural differences confront challenges (51). Moreover, the greater the dialect cultural differences, the higher the communication cost between rural migrants and public health

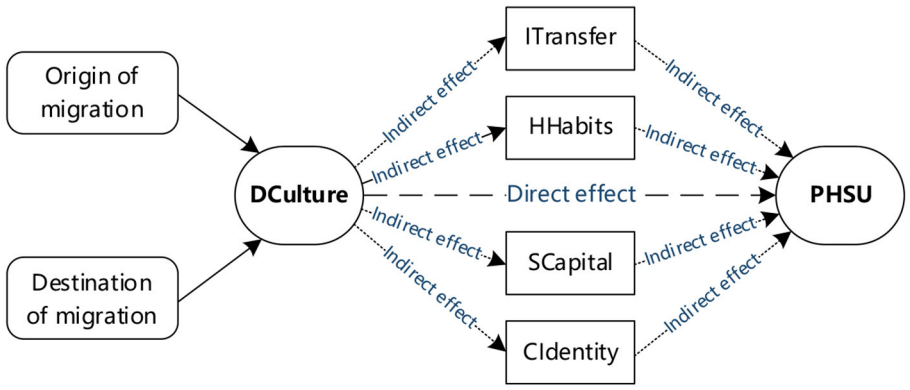

FIGURE 1
Framework operationalized in the current study.

service providers, and the greater the barriers to information transmission. Thus, it reduces the utilization rate of public health services. Secondly, the more significant the dialect cultural difference between the source and destination of rural migrants, the greater the difficulty in the cultural adaptation of rural migrants, and the lower the degree of convergence with residents' health habits and lifestyles (52). So, it will create barriers and hinder the utilization of public health services. Thirdly, due to the impact of regional culture, rural migrants who have left their hometowns are more inclined to interact with their villager fellows having similar cultures, which results in the lack of ways to extend outwards and the inability to establish and expand social networks and reconstruct social capital in the influx of cities. That further makes it difficult to obtain accurate information on local public health service projects and ultimately results in the low utilization rate of public health services. Finally, it is difficult for individuals with different regional and cultural backgrounds to establish a trusting relationship and a sense of cultural identity due to differences in their way of thinking, value orientation, and behavioral norms. Cross-cultural mobility is likely leading to a gap of trust between rural migrants and public health services, so rural migrant workers are inactive to respond to the public health service's management, and health education inhibits them from using public health services. Thus, this paper constructs the analytical framework shown in Figure 1 and proposes the following research hypotheses:

H1: Dialect culture ("DCulture") significantly hinders the utilization of public health services ("PHSU") for rural migrants.
H2: DCulture indirectly hinders rural migrants' access to PHSU through information transfer ("ITransfer"), healthy habits ("Hhabits"), social capital ("SCapital"), and cultural identity ("CIdentity").

Methodology

Data sources

This study used data from China Migrants Dynamic Survey ("CMDS") for 2017. This survey was conducted by the National Health and Family Planning Commission of China, which is authoritative and time-sensitive. The survey adopted the stratified, multi-stage, and probability proportionate to size sampling method. The survey covers the inflow places where the floating population is relatively concentrated among mainland China's 31 provincial-level administrative units. The data is collected from people aged 15 and above without household registration in the district (county, city). The survey content involves the basic information of the floating population and their family members, the scope and trend of migration, the utilization of essential public health services, and the management status of marriage, childbirth and family planning services, etc., which has both professional, scientific and large-scale characteristics, and can comprehensively describe the utilization of public health services of rural migrants in China. The total number of CMDS2017 data samples is 169,989. Since this study focuses on the rural immigrant group and only the floating population who has lived locally for more than 6 months and used essential public health services, the valid screened samples found are around 117,108.

Study variables

Explained variables

The explained variable in the current study is "utilization of public health services." "Documentation of health records" is employed as the indicator reflecting the utilization of public health services of rural migrants. The reason is that the current

territorial governments mainly rely on health records to carry out health education, prevention, and control of infectious diseases for the floating population and pregnant women. In the questionnaire, this indicator was operationalized as "whether a resident health file has been established for you," and the respondents answered "yes, it has been established," "not established, never heard of it," "not established, but heard of it" and "Unclear." This paper assigns "Yes, has been established" to 1, and other cases are assigned to 0. According to the data, it is found that around 33,634 rural migrants have established health records within the sample, accounting for 28.72%.

Explanatory variable

The introduction explains that China has a vast territory, substantial cultural differences across regions, and diverse Chinese dialects. Rural migrants face enormous language challenges in adapting to life in their places of origin. Although Mandarin is regarded as a formal and official language of China daily, rural migrants mostly use the Chinese dialect as the mode of communication and social interaction (50). At the same time, language is a comprehensive representation of culture, which can account for culture's inheritance, differentiation, and assimilation. Therefore, based on the current research results and the particular national conditions of China's multilingualism, this study constructed dialect cultural indicators based on the geographical distribution of dialects. According to the Chinese dialect division in the 2020 "Chinese Dialect Dictionary (Revised Version)," the Chinese dialect level in China is divided into three levels: dialect region, dialect area, and dialect piece. Accordingly, there are ten major dialect regions, 17 dialect areas, and 97 dialect pieces, covering 2,596 counties (cities, districts, and flags). Figure 2 shows the geographic distribution of the 10 Chinese dialect region. As shown in Figure 2, Chinese dialect areas in China vary greatly from provincial boundaries; a province may have multiple dialect areas, and a dialect area may also span multiple provinces. Overall, Mandarin is the most spoken Chinese dialect.

Although the unit of dialect is different from the administrative unit, there is often only one dialect piece in a county. Drawing on the research of Liu et al. (53), this paper first uses 97 dialect pieces to identify the language types of the counties in the origin and inflow of rural migrants. It then measures the dialects and cultural differences between the origin and inflow of rural migrants based on the dialect distance between the counties. The specific rules are as follows: when two counties belong to the same dialect piece, the dialect distance between the counties is 1; when they belong to different dialect pieces in the same dialect area, the dialect distance is 2; when they belong to different dialect area in the same larger dialect area, the dialect distance is 3; when they belong to different larger dialect area, the dialect distance is 4. The larger the value, the more significant is the dialectal cultural difference between the source and inflow areas of rural migrants. Among the rural migrants, it is found that about 31.01% of the same dialect moved, 17.43% of different dialects piece in the same dialect area, 17.99% of different dialects area in the same larger dialect area, and 33.57% of different larger dialect area.

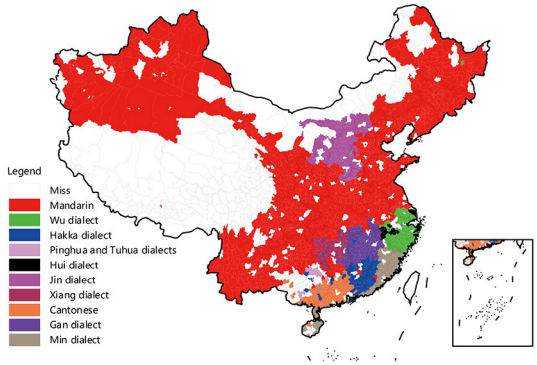

FIGURE 2
The geographic distribution of the ten major dialect regions in China [Data source: The Chinese Dialect Dictionary (Revised Edition)].

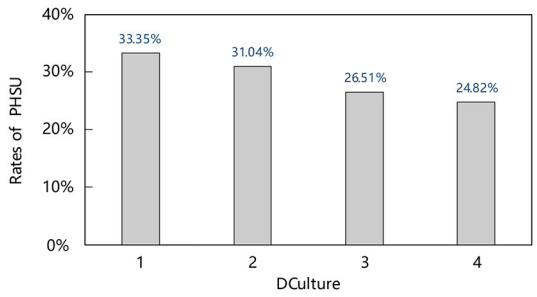

FIGURE 3
Rates of PHSU among rural migrants in different DCulture.

Figure 3 further intuitively presents the utilization of public health services for rural migrants under different dialect and cultural differences. According to the figure, it is shown that the more significant the dialect cultural difference, the lower the utilization rate of public health services for rural migrants. Specifically, 33.35% of rural migrants in the same dialect area have established health records, 31.04% in the same dialect area with different dialect pieces, 26.51% in the same dialect region with different dialect areas, and the proportion of rural migrants flowing in different dialect region was only 24.82%. This shows that dialect culture hinders the utilization of public health services for rural migrants, but the causal relationship needs further testing.

Other variables

It is believed that dialect culture is an endogenous variable. So in this regard, the current study uses the absolute value of the difference between the topographic relief of the source of rural migrants and the topographical relief of the inflow area as an exogenous geographic instrument variable. The data comes from the Global Change Scientific Research Data Publishing System (www.geodoi.ac.cn). The reasons for using the difference in terrain relief as a geographic instrument variable are as follows: Generally speaking, the greater the degree of surface segmentation in a particular area, the higher the average elevation. And the greater the degrees of mountain relief, the more efficiently the area's residents are affected by such a complex geographical environment in China. And the isolation of the geographical environment leads to the relative independence of language communication and cultural development between different communities, which have evolved into cultural differences and dialect diversity between regions for a long time (53, 54). Therefore, the topographic relief difference and the dialect cultural variables should be positively correlated. Still, the topographic relief is a natural geographical condition formed in the region's history, which exists objectively and is not directly related to the utilization of public health services for rural migrants. Therefore, the terrain relief difference is regarded as a more appropriate instrument variable in the current study.

The paper further considers information transmission, health habits, social capital, and cultural identity to assess the mechanisms of dialect culture that influence the utilization of public health services for rural migrants. The information transmission is measured by the questionnaire item "Have you heard of the national basic public health service project." The options to this question include "heard of" and "haven't heard of it, "which assign a value of 1 and 0, respectively. Within the sample, it was found that about 69,224 rural migrants had heard of the national basic public health service project, accounting for 59.11%. Further, health habits are measured by items including, "My hygiene habits are quite different from those of local citizens," and the options include "completely agree," "basically agree," "disagree," and "completely disagree." "Disagree" and "Totally disagree" are combined and assigned a value of 1, and "completely agree" and "basically agree" are assigned a value of 0. Within the sample, about 93,459 rural migrants did not agree that their hygiene habits differed from local citizens, accounting for 79.81%. Furthermore, social capital is measured by "who do you interact with the most in your spare time (excluding customers and other relatives)," and the respondents answered the options, including "compatriots," "other locals," "other foreigners," and "rarely with people." This paper combines "other locals" and "other foreigners" and assigned a value of 1, and the rest of the cases are assigned a value of 0. Within the sample range, 49,009 rural migrants have the most exchanges with foreigners and locals in their spare time, accounting for 41.85%. Cultural identity is measured by "it is more important for me to do things according to the customs and habits of my hometown." The options answered by the respondents include "completely agree," "basically agree," "disagree," and "completely disagree." "Totally Disagree" is merged with a value of 1, and "Totally Agree" and "Basically Agree" are assigned a value of 0. Within the sample, 49,772 rural migrants, or 42.50%, do not agree that it is vital to do things according to the customs of their hometown.

The study also controlled for various potential confounding factors that may simultaneously affect the utilization of rural migrants' public health services and migration decisions, mainly including gender, age, marital status, education level, self-assessment of health, migration time, range of migration, income level, medical distance, medical insurance, etc. In addition, considering the differences in the level of social and economic development in different cities, this paper matches the "China Urban Statistical Yearbook 2017" with the CMDS 2017 data and selects urban characteristics such as the level of medical services and city size in the inflow area as control variables. The definition of variables with their descriptive statistics is shown in Table 1.

Model specification

Main effects model

Since the explained variable of the utilization of public health service in this paper is a discrete binary variable, so the probit model is used for estimation. The expression for this model is:

$$y_i^* = \alpha + \beta x_i + \gamma s_i + \varepsilon_i \quad (1)$$

$$y_i = \begin{cases} 1, & y_i^* > 0 \\ 0, & y_i^* \leq 0 \end{cases} \quad (2)$$

As shown in formula (1), y_i^* represents the latent variable of the utilization of public health services for rural migrants. When $y_i* > 0$, $y_i = 1$, or $y_i = 0_\circ$ x_i represents dialect culture, s_i are a series of control variables, mainly including gender, age, marital status, education level, self-assessment of health, migration time, range of migration, income level, distance from medical treatment, medical insurance, medical service level and city size. α, β, γ are parameters to be estimated, ε_i is a random disturbance term.

Instrument variable approach

The benchmark mentioned above is likely to have potential endogeneity issues for the following reasons. Firstly, the choice of the migration destination is based on costs and benefits. It results from self-selection to maximize income or utility rather than random selection. Directly estimating non-random

TABLE 1 Descriptive statistics.

Variables	Definition	Mean	Std. Dev.	Min	Max
PHSU	Utilization of Public Health Service: Established = 1; Other = 0	0.287	0.452	0	1
DCulture	Dialect culture: same dialect piece = 1; different dialect piece in the same dialect area = 2; different dialect areas in the same dialect region = 3; different dialect region = 4	2.541	1.241	1	4
Gender	Male = 1; Female = 0	0.515	0.500	0	1
Age	Respondent's age in 2017 (years)	35.905	10.565	15	96
Marriage	Married = 1; Unmarried = 0	0.834	0.372	0	1
Education	High school and above = 1, below high school = 0	0.332	0.471	0	1
Shealth	Healthy or basic health = 1; unhealthy but able to take care of life or unable to take care of life = 0	0.973	0.162	0	1
Rtime	Duration in the host city (years)	6.299	5.982	0	64
FRange	Scope of mobility: inter-provincial mobility = 1; intra-provincial inter-city = 2; intra-city inter-county = 3	1.707	0.760	1	3
HIncome	Income level: logarithm of monthly per income household income of respondents	7.561	0.734	0	11.513
HDistance	Distance to hospital: within 15 mins = 1; 15–30 mins = 2; 30 mins−1 h = 3; more than 1 h = 4	1.179	0.441	1	4
Medicare	Medical Insurance: participated = 1; Not Participated = 0	0.194	0.395	0	1
PHospital	Medical service Level: per capita hospitals flowing into the city in 2016	0.579	0.570	0.104	8.929
SCity	City size: small and medium cities = 1; large cities = 2; mega cities = 3; more mega cities = 4	1.987	0.928	1	4
Instrument variable	The absolute value of the difference between the relief of the source and the inflow	0.448	0.777	0	5.784
ITransfer	Information transmission: heard of = 1; never heard of = 0	0.591	0.492	0	1
HHabits	Healthy habits: disagree or totally disagree = 1; totally agree or basic agree = 0	0.798	0.401	0	1
SCapital	Social capital: other natives or other outsiders = 1; other = 0	0.418	0.493	0	1
CIdentity	Cultural identity: disagree or totally disagree = 1; totally agree or basic agree = 0	0.425	0.494	0	1

samples will cause selection bias. Secondly, dialect culture is the carrier of regional culture. The impact of dialect culture on the utilization of public health services for rural migrants may be due to the influence of other cultural factors rather than the dialect culture itself, such as customs and living habits. These bilateral factors, which reflect the differences between the source and inflow areas of rural migrants, may not only be related to the dialect culture between the two places but also are important factors affecting the utilization of public health services for rural migrants. However, such factors are difficult to measure and characterize accurately and are often ignored in research models, leading to missing variables. Endogenous problems, as stated above, lead to inconsistent estimated coefficients.

To fix this issue, the typical solution is the instrument variable approach. This paper attempts to use the IVprobit model to carry out regression analysis. The specific model settings are as follows:

$$y_i^* = a_0 + a_1 x_i + a_j s_i + u_i \tag{3}$$

$$x_i = \gamma_1 z_i + \gamma_2 s_i + v_i \tag{4}$$

$$y_i = \begin{cases} 1, \ y_i^* > 0 \\ 0, \ y_i^* \leq 0 \end{cases} \tag{5}$$

From formula (3) to formula (5), y_i is an observable dummy variable, y_i^* is an unobservable latent variable, x_i is the only endogenous variable in the model, z_i is an instrument variable, u_i and v_i is a random disturbance term. Suppose the disturbance term $(u_i, \ v_i)$ obeys a two-dimensional normal distribution with an expected value of 0. That is:

$$\begin{pmatrix} u_i \\ v_i \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho\sigma_v \\ \rho\sigma_v & \sigma_v^2 \end{pmatrix}\right] \tag{6}$$

In the equation, the variance of u_i is normalized to 1, and ρ is the correlation coefficient of $(u_i, \ v_i)$.

In addition, considering that the potential endogenous variable dialect culture is an ordered categorical variable, the IVprobit model ignores the ordered categorical variable attributes of dialect culture to a certain extent and cannot fully utilize the information, which results in the loss of estimation efficiency. So this paper further employs the Extended Probit ("Eprobit") model in the Extended Regression Mode framework for re-estimation. For more details, please refer to the regression tool "eprobit" used in STATA. This method uses the Full Information Maximum Likelihood estimation method, which

can more effectively deal with the endogenous variables, as in the case of ordinal categorical variables.

Mediation effect model

After analyzing the impact of dialect culture on rural migrants' public health service utilization, this paper further adopts Baron and Kenny's (55) mediation effect model, which takes information transmission, health habits, social capital, and cultural identity as mediating variables to examine the influence of dialect culture on rural migrants' public health services. In addition to formula (1) and formula (2), the specific path of health service utilization needs to construct the following measurement model:

$$m_i = b_0 + b_1 x_i + b_j s_i + \varepsilon_i \quad (7)$$

$$y_i^* = c_0 + c_1 x_i + c_2 m_i + c_j s_i + \varepsilon_i \quad (8)$$

$$y_i = \begin{cases} 1, \ y_i^* > 0 \\ 0, \ y_i^* \leq 0 \end{cases} \quad (9)$$

Among them, y_i^* represents the latent variable of the explained variable, when $y_i^* > 0, y_i = 1,$ otherwise, $y_i = 0$. x_i is the explanatory variable, and m_i is the mediator variable, including information transfer, healthy habits, social capital, and

TABLE 2 Probit estimates of the effects of DCulture on PHSU of rural migrants.

Variable	PHSU				
	(1)	(2)	(3)	(4)	(5)
DCulture	−0.082***	−0.040***	−0.049***	−0.026***	−0.008***
	(0.003)	(0.004)	(0.004)	(0.005)	(0.001)
Gender		−0.074***	−0.079***	−0.084***	−0.026***
		(0.008)	(0.008)	(0.008)	(0.003)
Age		0.000	0.000	0.000	0.000
		(0.000)	(0.000)	(0.000)	(0.000)
Marriage		0.165***	0.167***	0.138***	0.043***
		(0.012)	(0.012)	(0.012)	(0.004)
Education		0.052***	0.064***	0.060***	0.019***
		(0.009)	(0.009)	(0.010)	(0.003)
Shealth		0.097***	0.105***	0.110***	0.034***
		(0.026)	(0.026)	(0.027)	(0.008)
Rtime		−0.003***	−0.003***	−0.001	−0.000
		(0.001)	(0.001)	(0.001)	(0.000)
FRange		0.117***	0.076***	0.017**	0.005**
		(0.007)	(0.007)	(0.008)	(0.002)
HIncome		−0.028***	−0.015***	0.002	0.001
		(0.006)	(0.006)	(0.006)	(0.002)
HDistance		−0.102***	−0.100***	−0.083***	−0.026***
		(0.009)	(0.009)	(0.010)	(0.003)
Medicare		0.215***	0.246***	0.240***	0.075***
		(0.010)	(0.010)	(0.011)	(0.003)
PHospital			−0.011	0.043***	0.014***
			(0.008)	(0.008)	(0.003)
SCity			−0.095***	0.041***	0.013***
			(0.005)	(0.008)	(0.002)
Constant	−0.356***	−0.574***	−0.415***	−1.565***	
	(0.009)	(0.057)	(0.058)	(0.073)	
Province effects	NO	NO	NO	YES	YES
Wald chi-squared	683.390***	2039.550***	2494.800***	10636.390***	10636.390***
Pseudo R^2	0.005	0.015	0.018	0.081	
Observations	117,108	117,108	117,108	117,108	117,108

Robust standard errors in parentheses. ***$p < 0.01$, **$p < 0.05$. Marginal effect are reported in column (5) of this table.

cultural identity. Based on the fact that Equations (1) and (2) have confirmed that dialect culture significantly hinders the public health services utilization for rural migrants, if both b_1 and c_2 are significant, there is an indirect effect. At this time, when c_1 is not significant, there is a full mediation effect; when c_1 is significant, there is a partial mediation effect.

In addition, considering that the mediation effect model proposed by Baron and Kenny is mainly aimed at the case where the explained variable is continuous, and to avoid potential bias in the estimation results, this paper adopts the KHB method proposed by Karlson et al. (56), which is suitable for the case where the explained variable is a discrete variable to test the robustness of the mediation effect.

Empirical results

Baseline regression results

Table 2 reports the benchmark regression results of the impact of dialect culture on rural migrants' utilization of public health services. To verify the robustness of the regression results, this paper adopts a stepwise regression method. Column (1) only controls the core explanatory variables, column (2) includes individual characteristics, column (3) includes urban characteristics, column (4) includes provincial dummy variables, and column (5) is the marginal effect of the estimated outcome of column (4). From the results in Table 2, it can be seen that whether only the core explanatory variables are controlled, individual characteristics, urban characteristics, or provincial dummy variables are added, the negative impact of dialect culture on the utilization of public health services for rural migrants is significant at the 1% level, indicating that the estimation results are robust. From the results in column (5), it can be seen that each time the dialect distance increases by one level, the possibility of rural migrants' utilization of public health services will decrease by 0.8%. The above results show that the more significant the dialect cultural difference, the lower the utilization of public health services for rural migrants. Thus, hypothesis 1 is preliminarily confirmed.

Further, the control variables found that comparatively rural female migrants, rural male migrants had significantly lowers utilization of public health services. Moreover, marital status, education level, self-assessment of health, mobility range, and medical insurance significantly and positively influence the rural migrants' public health service utilization, meaning being married, having a high school education or above, physical health, closer mobility range, and having medical insurance of rural migrants have significantly higher utilization of public health services. The further the distance to seek medical treatment, the lower the utilization of public health services for rural migrants. The results of urban characteristics show that the areas' medical service level and city size significantly improve the utilization of public health services for rural migrants.

Instrument variable result

Table 3 reports the estimated results of the IVprobit model. From the estimation results of the first stage of the IVprobit model in column (1), the instrument variable has a significant positive impact on dialect culture, which means that the instrument variable satisfies the correlation condition. From the estimation results of the second stage of the IVprobit model in column (2), the endogeneity test parameter of dialect culture is significant at the 1% level, indicating that dialect culture is indeed an endogenous variable, and the endogenous variable is just identified. The Anderson-Rubin test statistic also shows that the model does not have the problem of weak instrument variables, and the estimation results of the IVprobit model are more robust than the Probit model. From the estimation results, it is found that dialect and cultural differences significantly hinder the utilization of public health services for rural migrants; it can be seen that the negative impact of dialect culture on the utilization of public health services for rural migrants is robust, and research hypothesis 1 is further confirmed.

TABLE 3 IVprobit and Eprobit estimates of the effects of DCulture on PHSU of rural migrants.

Variable	IVprobit		Eprobit	
	(1)	(2)	(3)	(4)
	DCulture	PHSU	DCulture	PHSU
DCulture		−0.168***		−0.088***
		(0.039)		(0.017)
Instrument variable	0.199***		0.450***	
	(0.005)		(0.004)	
Wald test of exogeneity		13.100***		
AR weak Instrument variable test		18.180***		
Corr(e.Dculture, e.PHSU)				0.075***
				(0.021)
Constant	4.062***	−0.965***	2.339***	−1.395***
	(0.043)	(0.182)	(0.004)	(0.088)
Control variables	Yes	Yes	Yes	Yes
Province effects	Yes	Yes	Yes	Yes
Wald chi-squared		10,485.600***		10,389.880***
R^2	0.526			
Observations	117,108	117,108	117,108	117,108

Robust standard errors in parentheses. ***$p < 0.01$.

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TABLE 4 Robustness test results.

Variable	PHSU				
	(1)	(2)	(3)	(4)	(5)
	Key cities	Intra-city migration	Work and business	Under 60 years of age	Melogit
DCulture	−0.014*	−0.046***	−0.023***	−0.026***	−0.016*
	(0.008)	(0.011)	(0.005)	(0.005)	(0.009)
Constant	−1.925***	−0.885***	−1.567***	−1.542***	−3.415***
	(0.188)	(0.131)	(0.084)	(0.076)	(1.157)
Control variables	Yes	Yes	Yes	Yes	Yes
Province effects	Yes	Yes	Yes	Yes	Yes
Pseudo R^2	0.120	0.060	0.083	0.081	
var(_cons[city])					1.029***
					(0.102)
ICC					0.238***
					(0.018)
Observations	48,073	21,700	99,453	114,049	117,108

Robust standard errors in parentheses. ***$p < 0.01$, *$p < 0.10$.

This paper further uses the Eprobit model, and according to the results in column (3), it can be seen that the instrument variables have a significant positive impact on the dialect culture, which also verifies that the instrument variables meet the correlation requirements. The main regression results in column (4) show that dialect culture significantly and negatively impacts the utilization of public health services for rural migrants, with a coefficient of −0.088. Compared with the coefficient in column (2), the coefficient becomes smaller, and the standard error decreases. It shows that the IVprobit model estimation has the problem of validity loss. The correlation test of residual items showed that the correlation between the regression model of endogenous variables and the primary regression model is significant, indicating that dialect culture is indeed an endogenous variable. After endogenous treatment, dialect culture significantly negatively impacts the utilization of public health services for rural migrants, which is highly consistent with the results of the IVprobit and probit models.

Robustness check

Considering the endogenous problems such as sample selection and missing variables in the empirical model, this paper alleviates the problem by adding as many control variables as possible. It uses the instrument variable method to test the robustness of the analysis results. To further verify the reliability of the empirical results, this paper also uses four methods to conduct robustness tests, as shown in Table 4. First, the National Health and Family Planning Commission of China issued the Pilot Work Plan for Equalization of Basic Public Services for Health and Family Planning for Floating Population in 2013. Currently, there are 31 provincial-level administrative units in 44 cities with a high concentration of floating population in mainland China (see Table A1). Carry out pilot work on equalizing essential public services for health and family planning for the floating population. Rural migrants in the above 44 cities are likely to enjoy the same rights of public health services as residents. To better identify the impact of dialect culture on the utilization of public health services for rural migrants, this paper only retained samples from 44 key cities for robustness testing.

The regression results are shown in column (1), and according to the results, it is found that the coefficient of dialect culture is significantly negative; indicating that even in 44 key cities, dialect culture still negatively impacts rural migrants' utilization of public health services. Secondly, in the city, urban and rural residents can enjoy public health services in the same city. Therefore, this paper only retained the samples that flow across counties within the city for robustness testing, and the regression results are shown in column (2). The results show that the coefficient of dialect culture is significantly negative; indicating that dialect culture still significantly reduces the probability of rural migrants' utilization of public health services even if they move to cities. Thirdly, only the samples of rural migrants who migrated for work and business were retained for robustness testing, and the regression results are shown in column (3). The results showed that dialect culture is significant, and the coefficient is negative, indicating that dialect culture still has a significant negative impact on the utilization of public health services for rural migrants. Fourthly, 3,059 rural migrants aged 60 and over in the sample used for the benchmark regression have reached the statutory retirement age but are still working.

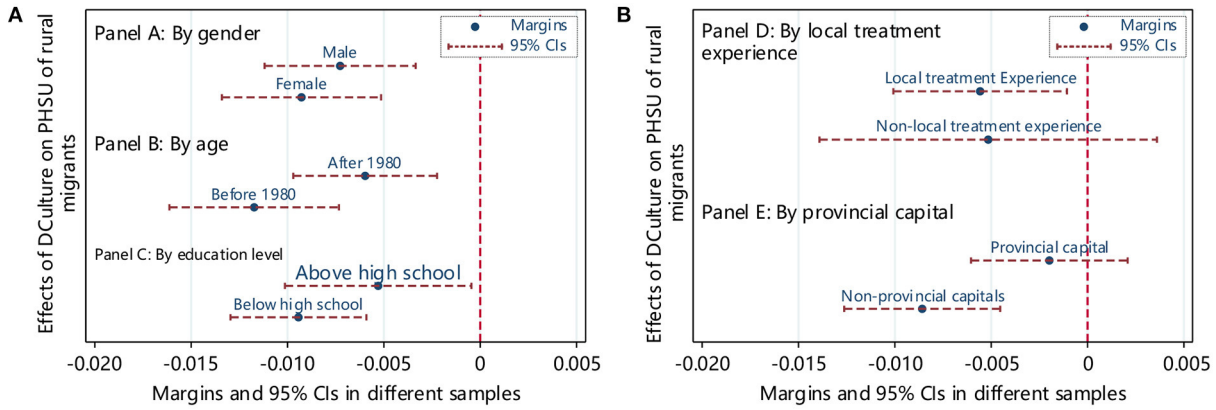

FIGURE 4
(A,B) The heterogeneous effect of DCulture on PHSU of rural migrants. The control variables introduced in the model fit were consistent with those in Table 2.

To further verify the robustness of the benchmark regression results, this paper only retained a sample of rural migrants under the age of 60 and re-estimated the impact of dialect culture on the utilization of public health services for rural migrants. The regression results in column (4) showed that dialect culture is negatively significant; indicating that dialect culture still significantly reduces the probability of rural migrants' utilization of public health services. Fifthly, Considering the regional effect of dialect culture, we re-estimated the relationship between dialect culture and rural migrants' public health service utilization using the melogit model, and the regression results are shown in column (5). The results show that the coefficient of dialect culture is significantly negative. Finally, it was considered that the use of ordered categorical variables to measure dialect culture differences between the origin and inflow of rural migrants may be biased because it implies that the distinction of the dialect culture differences between different situations are equal. Therefore, we examined the cases where rural migrants' source and inflow locations belonged to the same dialect piece, dialect area, and dialect region, respectively, as shown in columns (1), (2), and (3) of Table A2. The results show that same dialect mobility always exhibits higher utilization of public health services, regardless of the stratum. Furthermore, to make the results more refined, we compare only the cases where the dialects of the origin and inflow of rural migrants are exactly the same vs. completely different, and the results in column (4) of Table A2 show that same dialect area mobility significantly contributes to rural migrants' public health service utilization.

Heterogeneity analysis

The previous analysis has confirmed that dialect culture hinders rural migrants' access to public health services but did not consider the heterogeneity. To obtain more detailed findings, the current study analyzed the heterogeneity from the perspective of migrating individuals and regions. The specific estimation results are shown in Figure 4.

Panels A, B, and C showed the grouped regression results based on gender, age, and education level. The results show that dialect culture significantly and negatively influences the utilization of public health services for rural migrants of different genders, ages, and educational levels. However, compared with males, rural migrants born after 1980 and with a high school education or above, dialect culture has a more significant impact on the utilization of public health services for women rural migrants born before 1980 and with below high school education. In addition, the group regression method to examine heterogeneity may be biased, so the current study employed the seemingly uncorrelated model (Suest) to test the differences between groups. The Suest test results showed that after grouping by gender, age, and education level, the coefficient differences between the groups are all significant at a 1% level, which further showed that the impact of dialect culture on the utilization of public health services for rural migrants is different based on gender and ages. And there are significant differences between groups with different educational levels. Panel D shows the difference based on having local medical treatment experience. The dialect cultural barriers of rural migrants without local medical treatment experience are insignificant.

In contrast, rural migrants with local medical treatment experience are more likely to reduce the utilization of public health services due to dialect and cultural differences. Panel E shows the difference between inflowing and non-provincial capital cities. The sample dialect culture of inflowing provincial capital cities is no longer significantly negative. Compared with provincial capital cities, dialect culture hinders public health services utilization for rural migrants who do not flow into provincial capital cities.

Mediation analysis results

The results of the mediation effect analysis are shown in Table A3, columns (1)–(4) test the influence of dialect culture on the mediating variable, and columns (5)–(8) test the dialect culture and the four mediator variables included in the model on the utilization of public health services for rural migrants. Column (9) is listed as dialect culture, and the four intermediary variables are simultaneously included in the model for exploring the effects of rural migrants on the utilization of public health services. Columns (1)–(4) show that the regression coefficients of dialect culture on information transmission, healthy habits, social capital, and cultural identity of rural migrants are significantly negative; columns (5)–(8) show respectively that information transmission, health. The regression coefficients of habits, social capital and cultural identity on the use of public health services for rural migrants are all significantly positive; (9) under the control of dialect culture, information transmission, healthy habits, social capital and cultural identity, the coefficient of dialect culture is significantly negative. In contrast, the regression coefficients of information transmission, health habits, social capital, and cultural identity are all significantly positive. The above results show that information transmission, health habits, social capital, and cultural identity are all channels that influence the public health services of rural migrants by dialect culture.

In addition, the current study also estimated the mediating effects of information transfer, healthy habits, social capital, and cultural identity by employing the KHB method. The results of the KHB method are highly consistent with the estimation results obtained by the Baron and Kenny methods (see Table A4). According to the results, it is apparent that dialect culture indirectly hinders rural migrants' utilization of public health services through information transfer, healthy habits, social capital, and cultural identity, which further confirms the robustness of the results of the mediation effect. Thus Hypothesis 2 is also confirmed.

Discussions

At present, the outburst of the COVID-19 pandemic has evolved into a global public health crisis (57, 58). Generally, it is regarded as a human, economic and social crisis. For preventing and controlling pandemics, the crucial role of the public health system cannot be ignored that upshot the urgent need to accelerate the improvement of the public health service system. Guo et al. (59) proposed to develop a sustainable social welfare system in China. In China, the quality of public health services accepted by rural migrants has become the "test gold stone" for the operation of the public health service system. However, as an essential carrier and symbol of regional culture, dialects, in addition to the function of communication, also represent the diverse cultural traditions and differentiated thinking habits of the language. In this study, we evaluated the impact of dialect culture on the utilization of rural migration public health services. According to the findings, it is apparent that the difference in dialect culture hinders the use of public health services for rural migrants. It infers that rural migrants have grown in a specific regional culture for a long time. After moving to cities, they are reluctant to adapt to new regional cultures. Moreover, rural migrants are more likely to be threatened by health threats due to high vocational risks and harsh living environments. It is easy to become blind spots for immunization, infectious disease prevention and control, and occupational health protection.

Furthermore, the cultural differences in dialect also led to information exchange between different groups, increasing information friction and restricting information exchange, and increasing the cost of collecting rural migration information (60), thereby hindering the spread of public health services policies. Therefore, it becomes difficult for rural migrants to accurately obtain information on local public health service projects, resulting in low use of their public health services. The findings corroborated the previous study by Wang et al. (61), who also showed that proficiency in Mandarin improves people's health and daily activities. Likewise, Strassmayr (62), in the case of developed countries, also exhibited the same findings and revealed that poor communication and cultural misunderstandings hinder public health services. Another finding is that comparatively rural male migrants born after 1980, and with high school or above, the dialect culture significantly hinders rural migrants born before 1980 and below high school. This means that women, the older and low-education rural migrants, are facing more cultural barriers and health inequality. The results are analogous to the recent studies that unveiled that rural women in developing countries confront cultural barriers (42, 63–65). The study proposes that government should promote and equalize essential health and public services primarily for the marginalized and deprived population following the study of Aziz et al. (66, 67). At the same time, rural migrants seeking medical treatment locally substantially affect their awareness of using public health services in the inflow place. Studies have found that the cultural hindrance of rural migrants with no local medical experience is insignificant. Rural migrants with local medical experience are more likely to reduce public health services due to cultural differences. This shows that when rural migrants encounter diseases and experience the public health services flowing place, the cultural obstacle of the dialect occurs. When rural migrants are healthy, dialect culture's impact is insignificant.

Moreover, the results of cultural hinders of rural migration dialects flowing into the provincial capital cities are no longer found to be significantly negative. Compared to non-provincial cities, migrants flow into the provincial capital cities obtains more public health services. The reason is that the provincial

capital cities have more high-quality medical resources, and the service supply methods of grass-roots medical institutions make the rural migrants more accessible to health services. At the same time, as a political, economic, and cultural center in each province, the cultural diversity and inclusiveness of the provincial capital cities are more robust. The above findings provide a valuable reference for the provision of required public health service projects in government groups and regions. In addition, the current study finds that dialect culture indirectly hinders the public health services to rural migrants through information transmission, health habits, social capital, and cultural identity. The main reason behind this hindrance is the differences in Chinese dialects, voices, tone, and vocabulary that influence the information transmission and create challenges in using rural migration public health services. The results are parallel to the findings of Chen (68), who also revealed that language expressions directly affect the people's health in the long term (68). Likewise, Flores (69) also exhibited the same findings in the case of American medical services and stated that language barriers seriously hamper the efficiency of American medical services (69). Similarly, Zanchetta and Poureslami (70) also found that language, religion, and culture often cause communication barriers and reduce the efficiency of public health services obtained by migrant workers. Another reason behind the indirect influence of dialect culture on public health services is that dialect culture subtly affects the behavior, habits, and lifestyle of rural migrants. The cultural habits of rural migrants are deeply ingrained, creating many challenges in adapting to the living habits of new cities; consequently, it makes it difficult for migrants to use the public health services effectively. Abraído-Lanza et al. (52) scrutinized the impact of cultural adaptation on Latin migrants' health behavior, and risk factors became more unfavorable with the degree of cultural adaptation.

Last, it is also found that the differences between dialect cultures increase the social distance between rural migrants and residents, making rural migrants easily marginalized. Leigh (71) inferred that language differences reduce the trust of locals and migrants and the general trust of migrants. The language barrier affects the health level by reducing the ability to establish social networks for the elderly flowing population (50). In another study, Tanis and Postmes (72) believed that social group identity is an important feature affecting people's perception and judgment of other groups' credibility (72). Rural migrants grew up in different regional cultures, and the trust gap causes rural migrants to respond to the health management of public health services differently, thus causing a reduction in the utilization of public health services by rural migrants. Finally, due to the common existence of regional discrimination and prejudice, cultural symbols form the cornerstone of cultural identity. Through social classification, rural migrants have identified their groups and produced internal group preferences and external group prejudice, which hinders the use of public health services (73). Rural migrants have formed their cultural values while moving to cities. Suppose the cultural differences between the dialects flow into and outflow places persist. In that case, it makes it difficult for them to adapt new cultural identity, eventually reducing the utilization of rural migrants' public health services.

Based on the above discussion, it is apparent that the Chinese geographical environment, natural conditions, and historical inheritance exhibit different dialect cultures. Dialectical culture affects the rural migrants' cognition, interaction, and strategy choices of public health services. This study comprehensively evaluated the hindrances, heterogeneity, and mechanisms of dialect cultural hinders generated by the cultural flow on rural migration public health services. From the perspective of dialects, the invisible barriers to the non-equalization of rural migrant's public health services provide a factual basis for further understanding the equalization of rural migrants and public health services and provide evidence to promote the equalization of rural migrant's public health services. In the context of normalized prevention and control of COVID-19, the government should actively carry out cross-regional cultural exchange activities to balance cultural diversity and unity in development, thereby breaking down cultural barriers to the utilization of public health services for rural migrants.

Conclusion and policy implications

Access to essential public health services is an essential aspect of social security. The quality of the services accepted by rural-to-urban migrants is a prominent reflection of the public health service system. However, it is also believed that the dialect culture influences the efficiency of public health policies. The current study aims to evaluate the impact of dialect culture on the utilization of rural public health services by rural migrants. By using the migrant data sourced from China Migrants Dynamic Survey (2017) and the dialect area information from the Chinese Dialect Dictionary (Revised Edition), the paper systematically examined the impact of dialect culture on the utilization of public health services for rural migrants. This study is enriching both cultural economics and health economics research literature in public goods provision. This paper finds that rural migrants with cross-cultural mobility face cultural barriers to public health equity, and dialect culture significantly hinders rural migrants' utilization of public health services, especially rural migrants who have local medical treatment experience and flow into non-provincial capital cities. In addition, the effect of dialect culture on the utilization of public health services by rural migrants not only directly but also indirectly hinders rural migrants' utilization of public health services through information transmission, healthy habits, social capital, and cultural identity.

In the normalization of prevention and control of COVID-19, the government should continuously optimize the public health service system, strengthen the publicity of essential

public health service projects, and increase the enthusiasm and initiative of rural migrants to use public health services. Carrying out dynamic monitoring of rural migrants' health and open services for electronic health records, gradually eliminating isolated information of essential health for rural migrants. Relying on big data to achieve precise services and health supervision and improve the overall efficiency of the public health service systems. In addition, we also call on countries to attach great importance to the impact of invisible barriers caused by cultural differences on the efficiency of public health policies when carrying out public health actions and continuously improve the breadth and depth of exchanges and interactions between regional cultures to strengthen regional cultural identity and trust relationship—enhancing the tolerance and recognition of rural migrant groups in various regions and weakening the regional concept and social exclusion of rural migrants to eliminate social distance caused by cross-cultural mobility. Finally, promote immigrant integration.

Moreover, this study is not without limitations. First, the CMDS data used in this paper are cross-sectional data, not a longitudinal survey of rural migrants. Using a fixed-effect model to control the impact of individual differences that do not change over time is impossible. It may be difficult to thoroughly and clearly describe the current utilization of rural migrants' public health services and the dynamic changes in the structure. Secondly, due to the data source, the dialect culture calculation in this study only involves the Chinese dialect and does not consider the dialect data in ethnic minority areas. Chinese ethnic minority cultures have their characteristics with a long history, and there may be communication barriers and trust gaps so the future research should consider adding ethnic minority areas and dialects.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

QZ wrote the main article. SX, NA, and YW revised and reviewed the article. JH supervised the article. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Gender differences in association of urbanization with psychological stress in Chinese adults: A population-based study

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Objective: To investigate the gender-specific associations between exposure to urbanization and psychological stress in China experiencing rapid urbanization.

Methods: Data were obtained from the 2015 China Health and Nutrition Survey. A total of 4,388 men and 5,098 women aged at least 18 years were obtained from 288 communities across 12 provinces and municipalities. Tertiles of the urbanization index, summarizing 12 urbanization dimensions at the community level, were used to define low, medium, and high levels of urbanization. The psychological stress was measured based on the 10-item Perceived Stress Scale. The gender-stratified multilevel analysis (Level-1: Individuals, Level-2: Communities, and Level-3: provinces/municipalities) was used to estimate the association between exposure to urbanization and psychological stress.

Results: After controlling for age, education status, marital status, work status, household income per capita, current smoking, alcohol drinking, sleep duration, BMI, and chronic conditions, the urbanization index was negatively associated with psychological stress in women ($P_{trend} = 0.017$) but not men ($P_{trend} = 0.476$). More specifically, a one-standard deviation increase in the score of community population density ($\beta = -0.329$, $P = 0.329$), modern markets ($\beta = -0.247$, $P = 0.044$), education ($\beta = -0.448$, $P = 0.002$), and housing ($\beta = -0.380$, $P = 0.005$) was negatively associated with psychological stress only in women, separately.

Conclusion: Our data revealed that living in the most urbanized communities is associated with lower levels of psychological stress for women but not men. Thus, this study can help empower decision-makers to accurately target vulnerable communities and plan effective strategies to address psychological outcomes.

KEYWORDS

China, urbanization, community, psychological stress, multilevel analysis

Introduction

Urbanization involves the change in size, density, and heterogeneity in places (1), and is widely recognized as a driver of the main health-relevant changes to humanity (2). Currently, more than 55% of the global population is living in urban areas. This proportion will increase to nearly 70% by 2050, with at least 50% of the population living in cities of more than 500,000 inhabitants (3). Rapid urbanization generated opportunities for improved sanitation, infrastructure, education, communication networks, and better health care services. Nevertheless, it resulted in traffic congestion, sedentary lifestyles, and environmental pollution (4–6). These factors can independently and synergistically influence individuals' health (7–9). A better understanding of their relationships may help us identify interventions that effectively promote health status in countries undergoing rapid urbanization.

China has witnessed unprecedented urbanization and associated rural depopulation over the past 40 years, along with a huge increase in the total population (10, 11). The rapid migration and urbanization process in China has led to pronounced changes in community composition and its characteristics (12), evoking great scholarly interest in the effects of urbanization on mental health for Chinese people (13–18). Most studies suggested an inverse relationship between urbanization and mental health (14, 16, 19), with urban living related to a lower prevalence of developing mental health problems (such as schizophrenia, dementia, cognitive impairment, and mood disorders) (14, 16, 17). Especially residence in highly urbanized areas was associated with lower depressive symptoms (20). However, few studies examined the association between exposure to urbanization and psychological stress in China. Psychological stress refers to the real or perceived environmental demands that exceed an individual's adaptive capacity in daily life (21, 22) and is considered the most well-established risk factor for mental disorders (23–25). It is, therefore, vital to obtain a comprehensive view of the complex and evolving relationship between urbanization and psychological stress for sustainable urbanization that can be deployed to protect mental health.

Moreover, rapid urbanization affects women and men in fundamentally different patterns (8, 26). Women and men may perceive, be exposed to, and respond differently to a growing urbanized environment (27). Meanwhile, gender affects each element in the stress process as much as the input by deciding whether a situation will be stressful at the output (28). Previous epidemiological studies have revealed that women are more likely to suffer from higher psychological stress than men (29–31) and develop greater mental health problems (14, 16, 17). Therefore, these observations suggest the possibility of gender-specific differences in the effects of urbanization on psychological stress. Thus, this study aimed to use data from the China Health and Nutrition Survey (CHNS) to explore the gender-specific association between urbanization and psychological stress, with a multidimensional index assessment at the community level.

Materials and methods

Study population and design

This study used data from CHNS, a longitudinal study that began in 1989 and has been repeated every 2–4 years through 2015 in 10 waves. The CHNS used a multistage, random cluster process to draw the sample surveyed in nine provinces (Liaoning, Heilongjiang, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi, and Guizhou) (32). The sample was designed to represent rural and urban areas of varying geography, economy, and public resources, and to focus on the overall health during urbanization and economic transitions (32). In 2011, three municipalities (Beijing, Chongqing, and Shanghai) directly under the Central Government were added to the study. The scientific rationale and design of the CHNS have been reported in detail elsewhere (33).

For the analysis, we included 20,899 participants over 18 years old from the 10th survey of the CHNS carried out in 2015, which measured psychological stress for the first time. Participants who had missing information on urbanization (n = 36), psychological stress (n = 1,413), or control variables including household income (n = 7,345), current smoking (n = 969), alcohol drinking (n = 4), sleep duration (n = 125), height (n = 1,512), or chronic conditions (n = 9) were excluded. Thus, 9,486 subjects (4,388 men and 5,098 women) from 288 communities across 12 provinces and municipalities were included in the final analysis.

Assessment of urbanization

We evaluated the urbanization level of the 288 sampled communities using an urbanization index developed by Jones-Smith and Popkin (34). Specifically, the urbanization index was applied to 12 multidimensional components at a community level: communications (e.g., television, mobile, post, and cinema), population density, economic activity, housing (i.e., availability of electricity, indoor tap water, and flushing toilets), traditional markets (i.e., types, distances, and business hours of food and fuel markets), modern markets (i.e., the quantity of supermarkets and modern eating establishments), social services, transportation, education (i.e., average educational level among adults above 21 years old), diversity (i.e., community variance in education and income levels), health infrastructure, and sanitation. Each component was scaled from 0 to 10, weighted equally in the overall index, and added together for an overall maximum possible score of 120. Higher scores reflected more urban characteristics across multiple domains. The urbanization index was explicitly developed for the CHNS and had adequate reliability and validity in previous

TABLE 1 Characteristics of the study population.

Characteristics	Overall	Men	Women	*P*-value
No. of participants	9,486	4,388	5,098	
Age (years)*	53 (43, 63)	54 (44, 64)	53 (42, 63)	0.003
Education status, *n* (%)				
Primary school and below	3,064 (32.3)	1,136 (25.89)	1,928 (37.82)	<0.001
Junior school	5,150 (54.29)	2,601 (59.28)	2,549 (50.00)	
Senior school and above	1,272 (13.41)	651 (14.84)	621 (12.18)	
Marital status, *n* (%)				
Married	8,328 (87.79)	3,935 (89.68)	4,393 (86.17)	<0.001
Others	1,158 (12.21)	453 (10.32)	705 (13.83)	
Work status, *n* (%)				
No	4,913 (51.79)	1,867 (42.55)	3,046 (59.75)	<0.001
Yes	4,573 (48.21)	2,521 (57.45)	2,052 (40.25)	
Household income per capita (10,000 yuan)*	1.77 (0.83, 3.20)	1.81 (0.87, 3.23)	1.73 (0.80,3.16)	0.012
Current smoking, *n* (%)				
No	7,302 (76.98)	2,315 (52.76)	4,987 (97.82)	<0.001
Yes	2,184 (23.02)	2,073 (47.24)	111 (2.18)	
Alcohol drinking, *n* (%)				
No	6,892 (72.65)	2,066 (47.08)	4,826 (94.66)	<0.001
Yes	2,594 (27.35)	2,322 (52.92)	272 (5.34)	
Sleep duration (hours), *n* (%)				
≤6	1,161 (12.24)	533 (12.15)	628 (12.32)	0.967
7–8	1,646 (17.35)	763 (17.39)	883 (17.32)	
≥9	6,679 (70.41)	3,092 (70.46)	3,587 (70.36)	
BMI, *n* (%)				
Underweight	1,363 (14.37)	621 (14.15)	742 (14.55)	<0.001
Normal	3,422 (36.07)	1,670 (38.06)	1,752 (34.37)	
Overweight	432 (4.55)	178 (4.06)	254 (4.98)	
Obesity	4,269 (45.00)	1,919 (43.73)	2,350 (46.10)	
Chronic conditions, *n* (%)				
No	7,540 (79.49)	3,439 (78.37)	4,101 (80.44)	0.013
Yes	1,946 (20.51)	949 (21.63)	997 (19.56)	
PSS-10*	16 (12,19)	16 (12,19)	17 (13,19)	<0.001

*Data were presented as median (P_{25}, P_{75}).
BMI, body mass index; PSS-10, Perceived Stress Scale-10.

studies (32, 35). The indicators measuring the proportion of households were derived from the household responses and the remaining indicators were collected from the community-level survey offered to community officials. The detailed construction procedure has been described elsewhere (34, 36, 37). Similar to prior studies, the urbanization index is categorized into tertiles representing low (<63.52), medium (63.52–84.07), and high (>84.07) urbanization levels.

Assessment of psychological stress

The Perceived Stress Scale-10 (PSS-10) was designed to measure the degree to which situations in one's life are appraised as stressful (38) and has been verified to assess psychological stress in a large community-based general population in China (24, 39). The PSS-10 is divided into two subscales: negative and positive. The negative subscale assesses the lack of control in life and negative affective reactions (perceived distress), while the positive subscale measures the ability to cope with current stressors (coping capacity) (38, 40). The participants rated each item on a 5-point Likert scale ranging from "0 = never" to "4 = very often. Positively framed questions (items 6, 7, 9, and 10) were reverse scored ("4 = never" to "0 = very often"), and all 10-item scores were then summed to create a total score. The total score ranged from 0 to 40 (Cronbach's $\alpha = 0.744$ in the present study), with higher scores indicating higher levels of psychological stress.

TABLE 2 Multilevel linear regression for the association between urbanization index and psychological stress, stratified by gender.

Urbanization index	Model 1*				Model 2†			
	β	SE	*P*-value	P_{trend}	β	SE	*P*-value	P_{trend}
Men								
Low	1.000 (ref.)	0.9	1.000 (ref.)	0.6				
Medium	−0.005	0.316	0.987		0.044	0.316	0.890	
High	−0.377	0.314	0.230		−0.219	0.321	0.496	
Women								
Low	1.000 (ref.)	0.1	1.000 (ref.)	0.7				
Medium	−0.777	0.309	0.012		−0.661	0.311	0.034	
High	−0.996	0.306	0.001		−0.775	0.316	0.014	

*Model 1: unadjusted.
† Model 2: adjusted for age (continuous), education status (primary school and below, junior school, or senior school and above), marital status (married or others), work status (yes or no), household income per capita (continuous), current smoking (yes or no), alcohol drinking (yes or no), sleep duration (≤6, 7–8, or ≥9 h), BMI (underweight, normal, overweight, or obesity), and chronic conditions (yes or no).
SE, standard error.

Assessment of control covariates

Trained interviewers collected individual information on sociodemographics, lifestyle parameters, and medical history with a structured questionnaire. The education status was divided into three categories (primary school and below, junior school, or senior school and above), and the marital status was categorized as married or others (including divorced, widowed, separated, or never married). The work status was divided into two categories (yes or no). The annual household income per capita (yuan) was calculated as the sum of the self-reported annual income of all adult family members divided by household size. Lifestyle factors included in the analysis were current smoking (yes or no), alcohol drinking (yes or no), and sleeping. Sleep duration was obtained by asking how many hours a person sleeps every day, including daytime and night time, and was categorized as ≤6 h, 7–8 h, or ≥9 h. The body mass index (BMI) was calculated as the weight (kg) divided by height (m) squared and was divided into four categorical groups based on the criteria recommended by the Working Group on Obesity in China (41): underweight (<18.5 kg/m^2), normal (18.5–23.9 kg/m^2), overweight (24.0–27.9 kg/m^2), or obesity (≥28.0 kg/m^2). Chronic conditions were measured by asking the respondents whether they had been diagnosed with chronic diseases (including hypertension, diabetes mellitus, stroke, myocardial infarction, or cancer) by professional doctors (yes or no).

Statistical analysis

Given that the continuous variables were of non-normal distribution, the results were presented as medians (P_{25}, P_{75}) for continuous variables and numbers (percentages) for categorized variables. The characteristics between men and women were compared using the Wilcoxon rank-sum test or Chi-squared test, as appropriate. Due to the prominent hierarchical characteristics of the data, individuals (level 1) nested within the community (level 2), and province/municipality (level 3) (42, 43), we used a gender-stratified multilevel (three-level) linear regression model to investigate the association between the community-level urbanization index and psychological stress. We developed two models, model 1 was unadjusted, and model 2 was adjusted for individual-level variables including age (continuous), education status, marital status, work status, household income per capita (continuous), current smoking, alcohol drinking, sleep duration, BMI, and chronic conditions. In addition, we examined whether each of the 12 urbanization components was separately associated with psychological stress. Given collinearity between the 12 urbanization components and to better understand the pathways linking exposure to urbanization and psychological stress, we conducted a separate analysis. We incorporated each of the 12 urbanization components [in one-standard deviation (SD) increase increments] in the model while adjusting for the covariates included in model 2 and stratifying by gender.

The statistical significance was determined at a two-sided *P*-value < 0.05 level, and all statistical analyses were conducted using SAS 9.4 (SAS Institute Inc., Cary, NC, USA) for Windows.

Results

Characteristics of the participants

Table 1 reports the characteristics of the 9,486 participants aged 18–99. The median (P_{25}, P_{75}) age of the total population was 53 (43, 63) years, with men having a higher median (P_{25}, P_{75}) age than women [54 (44, 64) vs. 53 (42, 63)]. Men were

TABLE 3 Multilevel linear regression for the association between urbanization components and psychological stress, stratified by gender.

Urbanization components	Model 1*			Model 2†		
	$\beta^{\ddagger}$	SE	*P*-value	$\beta^{\ddagger}$	SE	*P*-value
Men						
Communications	−0.247	0.129	0.056	−0.206	0.130	0.114
Population density	−0.115	0.140	0.413	−0.075	0.142	0.597
Social services	−0.242	0.125	0.052	−0.198	0.125	0.114
Traditional markets	−0.168	0.125	0.179	−0.123	0.125	0.323
Modern markets	−0.120	0.123	0.331	−0.074	0.124	0.551
Transportation	−0.064	0.122	0.599	−0.036	0.122	0.771
Economic activity	−0.140	0.131	0.287	−0.096	0.132	0.470
Education	−0.334	0.139	0.016	−0.239	0.146	0.101
Diversity	−0.243	0.128	0.058	−0.204	0.128	0.112
Health infrastructure	0.001	0.125	0.992	0.021	0.124	0.864
Housing	−0.313	0.133	0.019	−0.261	0.135	0.053
Sanitation	−0.152	0.126	0.228	−0.126	0.127	0.321
Women						
Communications	−0.215	0.128	0.093	−0.137	0.128	0.285
Population density	−0.387	0.137	0.005	−0.329	0.140	0.019
Social services	−0.284	0.123	0.021	−0.235	0.124	0.058
Traditional markets	−0.223	0.124	0.071	−0.154	0.124	0.213
Modern markets	−0.327	0.120	0.007	−0.247	0.123	0.044
Transportation	−0.250	0.120	0.037	−0.206	0.120	0.086
Economic activity	−0.290	0.129	0.024	−0.223	0.130	0.087
Education	−0.562	0.134	<0.001	−0.448	0.142	0.002
Diversity	−0.170	0.126	0.178	−0.121	0.126	0.339
Health infrastructure	0.010	0.123	0.935	0.044	0.122	0.719
Housing	−0.460	0.130	<0.001	−0.380	0.134	0.005
Sanitation	−0.308	0.125	0.014	−0.237	0.127	0.061

*Model 1: unadjusted.
† Model 2: adjusted for age (continuous), education status (primary school and below, junior school, or senior school and above), marital status (married or others), work status (yes or no), household income per capita (continuous), current smoking (yes or no), alcohol drinking (yes or no), sleep duration (≤6, 7–8, or ≥9 h), BMI (underweight, normal, overweight, or obesity), and chronic conditions (yes or no).
‡ β co-efficient representing the effect of a one-standard deviation increase in the component score.
SE, standard error.

more likely to be educated, married, employed, and have higher median household income per capita, whereas women smoked and drank less and had higher levels of obesity. Men more frequently reported a history of chronic conditions than women. The median (P_{25}, P_{75}) score of PSS-10 was 16 (12, 19) for men and 17 (13, 19) for women.

Urbanization index and psychological stress

Table 2 reports the multilevel-adjusted associations between the urbanization index and psychological stress. In men, no significant association between urbanization index and psychological stress was observed in model 1 ($P_{trend} = 0.209$) and model 2 ($P_{trend} = 0.476$). In women, model 1 presented a higher urbanization index associated with lower psychological stress ($P_{trend} = 0.001$). Regarding model 2, the association reduced but remained statistically significant when adjusting for age, education status, marital status, work status, household income per capita, current smoking, alcohol drinking, sleep duration, BMI, and chronic conditions ($P_{trend} = 0.017$). Specifically, women were significantly more likely to report a lower psychological stress medium ($\beta = -0.661$, $P = 0.034$) and high ($\beta = -0.775$, $P = 0.014$) levels of urbanization than low urbanization in model 2.

Urbanization components and psychological stress

The multilevel-adjusted associations of urbanization components (per one-SD increase) and psychological stress are presented in Table 3. In men, a one- SD increase in the score of

education and housing at the community level was separately associated with lower psychological stress in model 1, but the associations were not statistically significant when controlling for the variables in Model 2. In women, model 1 showed that a one-SD increase in the score of community population density, social services, modern markets, transportation, economic activity, education, housing, and sanitation was separately associated with lower psychological stress. Further adjustment for age, education status, marital status, work status, household income per capita, current smoking, alcohol drinking, sleep duration, BMI, and chronic conditions in Model 2, the increase in the score of community population density ($\beta = -0.329$, $P = 0.329$), modern markets ($\beta = -0.247$, $P = 0.044$), education ($\beta = -0.448$, $P = 0.002$), and housing ($\beta = -0.380$, $P = 0.005$) were still inversely associated with psychological stress, separately.

Discussion

To our knowledge, this study is the first to test potential gender differences in the association of urbanization with psychological stress in the CHNS data using multilevel analyses. Our gender-specific analysis showed that men and women had different patterns in the association between the urbanization index and psychological stress. By further analyzing the results, women appeared to be more sensitive to the urbanization components than men. Moreover, four urbanization components were separately and negatively associated with the levels of psychological stress in women levels after controlling for potential confounders.

This study found that the urbanization index was negatively associated with psychological stress in women but not men. Women in the most urbanized communities were likely to have lower levels of psychological stress than those in the low urbanized communities. No association was found in men, and the results for both genders remained consistent after adjusting for age, education status, marital status, work status, household income per capita, current smoking, alcohol drinking, sleep duration, BMI, and chronic conditions. Similar to this work, prior studies have reported that living in urban areas was associated with a lower suicide rate, with a consistently lower rate in women than in men (44, 45). One potential explanation for the observed gender difference may be partly that social roles determine the range of potentially stressful experiences of women and men (28). In China, women are equally stressed by work and family, whereas men are more vulnerable to the psychological impact of work roles than family roles (46). During China's urbanization, urban women, in contrast to rural women, are more likely to strive to become financially independent by doing more market work and less housework (47, 48) and eventually win better happiness (48). In addition, the mechanisms for the observed gender differences may also be related to the different coping strategies of men and women. This is explained by studies showing that women tend to use adaptive coping skills more and are more likely to seek social support than men (49–53). For example, women tend to be relatively more willing and able to access neighborhood social resources when faced with stressful life experiences (20). In contrast, men resist receiving or seeking formal support but are more willing to accept social support from families (54). Distinct from western countries, China's urbanization was greatly intervened by government policies (55, 56) and might promote neighborhood social capital (20, 56), increasing access to social networks and supports, regulating unhealthy behaviors, and promoting adaptive coping mechanisms associated with better psychological outcomes (57).

This study first examined the pathways linking 12 components of urbanization and psychological stress. It demonstrated that one SD increase in the score of community population density, modern markets, education, and housing was negatively associated with psychological stress only in women after controlling for age, education status, marital status, work status, household income per capita, current smoking, alcohol drinking, sleep duration, BMI, and chronic conditions. Living in crowded communities is associated with decreased psychological stress since population density is one of the most widely used proxies for access to medical and mental health professionals (58, 59). Therefore, mental health service providers tend to be heavily concentrated in densely populated urban areas (60). Melis et al. found that high population density contributed to a reduced risk of depression, especially for women (61). Additionally, greater access to modern markets was associated with lower levels of psychological stress. Living in a community with easier access to modern markets promotes access to healthy foods, resulting in lower life stress (62) and better happiness (63, 64). Brown et al. reported that greater accessibility and shopping in modern supermarkets were associated with better self-rated health (64, 65). Education at a community level was inversely associated with psychological stress because the neighborhood educational attainment was considered "collective human capital" (66) and "collective efficiency" (67), which may benefit the residents' health more than the sum of their efforts (68). Wight et al. indicated that living in a low-education area was associated with low cognitive function, net of individual characteristics, including individual-level education (69). Noteworthy, a house is a crucial family asset and is regarded as a potent status symbol in China (70). This study found that better housing conditions were inversely associated with psychological stress, consistent with previous studies, showing that inadequate housing conditions are associated with worsening mental health (i.e., stress, anxiety, and depression) (71–73). Although pathways have been proposed to elucidate this association, future studies are required to validate the

role of the other specific urbanization elements in improving psychological outcomes.

The strengths of this study were that the multicomponent urbanization index could capture heterogeneity in various services and infrastructures across different urbanized communities. We also evaluated how the pathways linking urbanization and psychological stress vary by gender, demonstrating a statistically significant association for women. The findings can help guide decision-makers to accurately target vulnerable communities and formulate effective policies to address psychological outcomes in China and other recently urbanized countries. However, there are several limitations to this study. First, the CHNS was not nationally representative, but encompassed communities from 12 different provincial regions in the northeast, central, and south China (27). This diversity makes this analysis possible (74). Second, the study was a cross-sectional design, limiting causality interpretations. Healthier people were more likely to migrate to more urbanized communities in search of better living conditions (20, 27, 75) because of the so-called healthy migrant effect (76). Third, this study decomposed urbanization and revealed that specific elements substantially affect psychological stress. Nevertheless, these single associations might be due to other factors associated with urbanization (77). Last, although measuring psychological stress in the CHNS has been validated (24, 39), it represents a self-reported perception of stress and is not an objective measurement. Future studies should attempt to replicate our analyses by measuring biological stress markers, such as cortisol levels (78–80).

Conclusion

The current study in a large sample of Chinese adults showed that a higher urbanization index was negatively associated with psychological stress in women but not men. More specifically, one SD increase in the score of community population density, modern markets, education and housing was separately and negatively associated with psychological stress only in women after controlling for potential confounders. These findings provide valuable insights that help guide decision-makers to accurately target vulnerable communities and allocate public resources to address psychological outcomes in the case of rapid urbanization.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://www.cpc.unc.edu/projects/china.

Ethics statement

The studies involving human participants were reviewed and approved by the Institutional Review Committees of the Institute for Nutrition and Health of Chinese Center for Disease Control and Prevention and the University of North Carolina at Chapel Hill, USA. The patients/participants provided their written informed consent to participate in this study.

Author contributions

DL conceived and designed the study, drafted the report, and received the final version for publication. YR conducted the statistical analysis. QK and CR revised the manuscript. All authors checked the article and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Urban living and chronic diseases in the presence of economic growth: Evidence from a long-term study in southeastern China

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High-speed urban development has brought about an increase in per capita income in low- and middle-income countries (LMICs) as well as the high prevalence rate of chronic diseases. Based on a study of chronic diseases from 2011 to 2021 in southeastern China, we used multivariate adjusted logistic regression method to analyze the effect of urban living on the incidence of typical chronic diseases and the trend of such effect with the improvement of public healthcare system. We adopted potential mediating risk factors of urban lifestyles including body mass index (BMI), frequency of dining out, sedentary time, and psychological distress in the adjusted estimation. Baseline results indicate a positive relationship between living in urban areas and the prevalence of type 2 diabetes, hyperlipidemia, and hypertension. Regarding the mediating factors, psychological distress had the highest positive coefficient (Cr) on type 2 diabetes, hyperlipidemia, and hypertension (Cr: 0.4881–0.7084), followed by BMI (Cr: 0.1042–0.1617) and frequency of dining out (Cr: 0.0311–0.0478), and finally, sedentary time (Cr: 0.0103–0.0147). However, regression results on the follow-up survey reveal that trend in the impact of living in urban areas on chronic disease diminished as the level of the healthcare system improved. Additionally, urban living was more positively correlated with the incidence of metabolic disease than with the incidence of cardiovascular disease and cancer. Our findings provide empirical evidence that future urban health planning in LMICs should pay sustained attention to upgrading the level of public health infrastructure covering urban residents as well as rural-to-urban migrants, constructing a long-term dynamic system of chronic disease prevention and control, and regularly monitoring the mental health problems of residents in order to interrupt the process of urban chronic disease prevalence in an early stage.

KEYWORDS

urban development, urban-rural disparity, psychological distress, nutrition shift, type 2 diabetes, public health management

Introduction

Urban development is a key indicator of global economic development. A number of countries and regions, particularly low- and middle-income countries (LMICs), have witnessed a significant upward trend in urban development in recent decades. The initial urban development process is driven by industrialization, in which enterprises that are engaged in production activities tend to concentrate the development geographically in order to acquire the economic benefits of agglomeration. High-speed urban development creates development opportunities for these countries and brings a series of changes to people's diet structures, lifestyles, and living environments. Simultaneously, the high prevalence of chronic diseases in such regions with remarkable economic growth has attracted academic attention (1).

Due to socioeconomic, cultural, and political differences, the impact of residence location on human health is complex and non-homogeneous in both temporal and regional dimensions (2). Although the relationship between urban lifestyles and chronic diseases in LMICs is inconclusive (3), there remain different views on this controversial issue. Previous research highlighted that urban living was accompanied by improvements in micronutrient intake and status, but also by increases in several risk factors for non-communicable diseases (4). According to an analysis of nationally representative data on LMICs, women living in higher per capita income and urban areas are associated with a higher probability of being overweight (5). Conversely, there is also the view that the income gradient in overweight individuals will go through a positive to negative change in the process of economic growth (6). Urban natural environments can even be a nature-based solution for improving public health (7).

As China's economy began to grow exponentially since 1978 when the "Reform and Opening-up" policy was launched, millions of rural people continued to migrate to cities (8), and between 2011 and 2021, the proportion of China's population living in urban areas increased from 51.83% to 63.89% (9). China's planning for cities began in the 1990s, and by the 21st century, cities had grown much larger than was expected at the former stage of city planning, which has led to a situation in which infrastructure and supporting policies have deviated from the actual population capacity and scale of cities (10). Nonetheless, the Chinese government is continuously committed to upgrading the basic health system, and the healthcare system reform undertaken by the Chinese government since 2009 has made commendable achievements, including the expansion of social health insurance, the reform of public hospitals, strengthening of primary health care, and the establishment of multiple initiatives to relax constraints on the growth of the private health care sector (11).

In this study, we explored the comprehensive mechanism of urban living on the prevalence of chronic diseases over a decade of rapid economic development in China (2011–2021). The results show that living in urban areas has significant positive effects on the incidence of typical chronic diseases, including type 2 diabetes, hyperlipidemia, and hypertension, but this effect tends to diminish as the level of urban basic medical standards improves. This finding underlines the significance of building parallel public health prevention and treatment systems in cities, and provides empirical evidence toward the critical role of welfare systems covering urban residents as well as rural-to-urban migrants. According to the projection of global urbanization (12), China's urbanization trend may continue for another four to five decades. Likewise, challenges may be posed in other LMICs with demographic structure similar to China. In this regard, research on the integrated pathogenic mechanism of urban living on chronic diseases should be multifaceted, worldwide, and simultaneously, an urgent matter.

This study makes several contributions to the literature. First, the relationship between living in urban areas and chronic disease has been studied by many authors, but most have focused on a specific mediator (e.g., nutritional transition, depression) (13–18). We adopted a broader range of potential mediators from the literature and make the contributions between risk factors comparable. Second, some previous studies were based on a set of cross-sectional data (19–21). This approach can observe the effect at a particular period, while it may ignore capturing the long-term trends; hence, we provided a longitudinal analysis using data from different time points and classified the impact of urban living on different types of chronic diseases, in an effort to develop a more targeted prevention and control system for chronic diseases. Finally, we discuss how non-conventional risk factors (mental illness) change the understanding of epidemiology in the context of urban development and what potential technological and demographic pressures they may pose on the capacity and efficiency of the future urban healthcare system (3). We aim to use this empirical study to provide systematic analysis and scientific insights toward modern cities' chronic disease prevention in developing countries with rapid economic growth as well as sustained population increase.

Potential risk factors for chronic diseases posed by urban living

We divided risk factors brought about by urban living into two types from the literature: physical and mental aspects. Physical factors refer to nutritional transitions and dietary habits differences caused by growth in per capita income. The acceleration of nutritional transition in cities contributing to their rapid increase in chronic diseases is based on the penetration of modern food systems into society, where the

main differences in diet composition have been the increase in refined carbohydrates, the addition of sweeteners, edible oils, and foods of animal origin, and the reduction of pulses and other vegetables. This shift has led to a sharp increase in body mass index (BMI) and waist circumference, which has caused the prevalence of chronic diseases including diabetes and hypertension (22). There may also be a correlation between the increased frequency of dining out due to urban development and the risk of diabetes and hyperglycemia. Increased frequency of dining out is likely to lead to higher fat, cholesterol, and carbohydrate intake, and lower micronutrient intake, particularly vitamin C, calcium, and iron (16).

Another physical risk is sedentariness and physical inactivity owing to technological advances. The prosperity of modern technology provides convenient transportation and makes sedentary habits common among urban residents (23). In a cross-sectional study, for older adults (age $\geq$ 60 years), the probability of having $\geq$2 chronic diseases was 76% higher for men who were sedentary for >4 h/day, and 82% higher for women who were sedentary for >4 h/day (24). Moreover, children with a chronic disease were found to be sedentary for an average of 10.2 $\pm$ 1.4 h/day, accounting for 76.5 $\pm$ 7.1% of the average time activity per day (25).

In addition to physical factors, mental problem is another pivotal mediating risk factor posed by urban living. Areas with high population densities are characterized by higher air pollution and noise, leading to a higher incidence rate of psychiatric disorders (26). Furthermore, the underlying social determinants of mental health, such as housing instability and food insecurity, unemployment, welfare and healthcare disparities, and educational inequity that are incompatible with the size of urban populations are becoming increasingly diversified and complex within the context of urban development (27–29). Prevalence rates of psychological distress, anxiety disorders, and post-traumatic stress disorder (PTSD) are higher in urban settings, where urban living influences the biological stress regulation pathways (17, 26). These mental problems brought about by urban environmental and socialization factors are potential mediators of urban living on the prevalence of typical chronic diseases. The accumulation of chronic stress may directly or indirectly result in the development of various diseases such as atherosclerosis, fatty liver disease (including non-alcoholic), and inflammation (30).

Although urban development has caused an increasing prevalence of chronic diseases in LMICs, it is undeniable that modernization has also accelerated the evolution of the healthcare system in the presence of economic growth. An indication of this is the four cross-cutting strategies proposed by the US Centers for Disease Control and Prevention (CDC): (1) epidemiology and surveillance to monitor trends to inform programs; (2) environmental approaches to promote health and support healthy behaviors; (3) health system interventions to improve effective utilization of clinical and other preventive services; and (4) community resources linked to clinical services to sustain chronic disease management. Combining these four strategies could prevent the onset of chronic diseases and promote early detection and mitigation of disease (31). While China is making progress in strengthening its primary healthcare system, there is more room for improvement in terms of controlling risk factors such as hypertension and diabetes. As China's healthcare reforms deepen, there is an opportunity to build an integrated, collaborative primary healthcare system that will better serve one-fifth of the world's population (32).

Materials and methods

Data

Data used in this study were obtained from two cross-sectional surveys. The baseline survey was conducted in Wuyishan City, Fujian Province, southeast China, from June 2011 to January 2012. A total of 7,268 residents in 54 communities of the city aged 40 to 75 years old were selected using a random sampling method, among them 6,589 residents agreed to participate and signed the informed consent form. Participants were interviewed using questionnaires on basic information concerning age, sex, marital status, employment status, smoking habits, emotional conditions, dietary habits, sedentary time, past medical history, and underwent a physical examination in Wuyishan Municipal Hospital, including BMI, waist circumference, fasting and 2-h postprandial plasma glucose levels, blood pressure (systolic and diastolic), lipid levels (total cholesterol, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol, and triglyceride). We excluded 181 participants in basic estimation and 645 participants in multivariate adjusted estimation due to incomplete information.

A follow-up visit was supplemented in 2021 for the 6,589 participants in the baseline survey, whose information was recollected in combination with telephone callbacks and a citywide medical network system database. Among them, 328 deceased and 178 with missing key information were excluded. We used government-defined urban and rural communities to classify the residence location of the participants, where the urban group includes people living in and around the centers of government-defined urban communities (33). First, compared to major metropolises in China, our study site was a typical small to medium-scale city. The urban development progress of the city has been in its primary stage and there is no significant aggregation effect of poor populations observed around urban communities. Second, adopting the classification standard consistent with government-defined urban and rural communities allows for identifying the type of healthcare services provided to the participants. Key explanatory variables (excluding discontinuous variables) in both datasets were

winsorized at the 1% and 99% quartiles to prevent disturbances from extreme values.

Conceptual model

We used the multivariate adjusted logistic regression method to explore the comprehensive mechanism of urban living on the incidence of typical chronic diseases, which essentially refers to the study on the association between urban living and non-communicable diseases (5, 34), and expanded on this in conjunction with analysis of aforementioned factors:

$$\mathbf{P(Y_{ij}=1)} = \frac{\mathbf{exp(Z)}}{\mathbf{1+exp(Z)}},$$
$$\mathbf{Z} = \boldsymbol{\alpha} + \boldsymbol{\beta_1}\mathbf{UL_i} + \mathbf{A_i^{'}}\,\boldsymbol{\beta_2} + \mathbf{Z_i^{'}}\,\boldsymbol{\gamma} + \boldsymbol{\varepsilon_i} \quad (1)$$

where $\mathbf{Y_{ij}}$ represents whether participant $\mathbf{i}$ has $\mathbf{j}$ chronic diseases (yes = 1, 0 otherwise), $\mathbf{UL_i}$ represents residence location of participant (living in urban areas = 1, 0 otherwise). Vector $\mathbf{A_i^{'}}$ is a set of mediating variables, whose risk level differences among participants were potentially posed by urban-rural living disparity, including BMI, frequency of dining out, sedentary time, and psychological distress. $\mathbf{Z_i^{'}}$ is control variable vector including gender, age, marital status, and smoking habits (19, 35).

When analyzing the relationship between urban living and chronic diseases, BMI, frequency of dining out, sedentary time, and psychological distress in the $\mathbf{A_i^{'}}$ vector were excluded due to potential mediation (36). In further examination of the specific effects of mediating risk factors, residence location can be adopted to capture unobserved fixed effects including level of medical services received by participants and degree of exposure to environmental changes. Variables classified as unmodifiable risk factors in the control variables vector were included in both basic and multivariate adjusted estimations (37).

Results

Descriptive statistics

In the multivariate adjusted regression based on the 2011 baseline survey, we eliminated 645 outliers due to missing values of key explanatory variables (incomplete physical examination or omission of questionnaire items) from 6,589 participants, and a total of 5,944 were eventually included in both basic and multivariate adjusted estimations. Characteristics of participants are shown in Table 1. In the baseline survey, participants were aged 40 to 75 years, with a mean value of 52.9717 years (St. Dev. = 8.8507); the proportion of the total sample from the urban area was 52.78%, which is in accordance with the local population distribution pattern.

The prevalence rates of type 2 diabetes, hyperlipidemia, and hypertension were 6.24%, 6.11%, and 5.97% in the full sample. Specifically, the prevalence rates were 8.42%, 8.73%, and 8.03%, for the urban population and 3.81%, 3.17%, and 3.67%, for the rural population. Regarding the mediating factors, the urban population had 1.37%, 1.06%, 9.07%, and 1.60% higher BMI, frequency of dining out, sedentary time, and psychological distress, respectively, than the rural population. Results of descriptive statistics have initially revealed a potential relationship between living in urban areas and chronic diseases. We have also provided baseline characteristics of the group that completed the follow-up visit and the group that lost to the follow-up visit due to decease (Supplementary material). Compared to the follow-up group, the deceased group had 18.98%, 131%, and 93.87% higher age, the prevalence rates of type 2 diabetes and hypertension, whilst 44.76% and 8.40% lower rates of marriage and employment, respectively. These results imply that aging, underlying chronic diseases, and the status of living alone impose substantial burdens on older people in China.

Baseline results

Tables 2, 3 present the baseline results. Coefficients (Cr) of residence location for type 2 diabetes (Cr = 0.8148, $p < 0.01$), hyperlipidemia (Cr = 1.1550, $p < 0.01$), and hypertension (Cr = 0.7498, $p < 0.01$) indicate a significantly positive relationship between urban living and the prevalence of chronic diseases (Table 2). For the control variables, age was positively correlated with the dependent variables (Cr: 0.0085–0.0660), which is consistent with previous studies (15, 18) and implies the challenges to the efficiency of the healthcare system posed by China's remarkable demographic shift (38).

In mediating factors, BMI, frequency of dining out, and psychological distress had substantial effects on type 2 diabetes, hyperlipidemia, and hypertension in the multivariable adjusted regression (Table 3). Sedentary time had a significant positive effect on type 2 diabetes and hyperlipidemia, but not on hypertension. Among these risk factors, psychological distress had the highest coefficient for chronic diseases (Cr: 0.4881–0.7084), followed by BMI (Cr: 0.1042–0.1617) and frequency of dining out (Cr: 0.0311–0.0478), and finally, sedentary time (Cr: 0.0103–0.0147). An additional level of psychological stress led to 48.81%, 70.84%, and 51.54% increases in the probability of having type 2 diabetes, hyperlipidemia, and hypertension, respectively.

From the aforementioned analysis, the nutritional shift may be reflected in an increase in residents' BMI or waist circumference (22). To test the robustness of the estimation, participants' waist circumference (cm) was used to replace the core explanatory variable BMI, and the results are reported in Table 4. Compared with the baseline regression, the influence direction and significance of other key explanatory variables did not change considerably, and waist circumference, as a proxy for

TABLE 1 Participant characteristics in the 2011 baseline survey.

Variables	Full sample		Urban		Rural	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Age (years)	52.9717	8.8507	53.3079	9.0659	52.5960	8.5898
Sex (Men = 1, Women = 2)	1.5384	0.4986	1.5952	0.4909	1.4749	0.4995
Residence location (Urban areas = 1, 0 Otherwise)	0.5278	0.4993	-	-	-	-
Marital status (Married = 1, Divorced or living alone = 0)	0.8728	0.3332	0.8690	0.3375	0.8771	0.3284
Employment status (Employed = 1, 0 Otherwise)	0.4539	0.4996	0.4734	0.5019	0.4321	0.4962
Cigarette smoking (Current smoking = 1, 0 otherwise)	0.2397	0.4935	0.1741	0.4493	0.3131	0.5292
BMI (Weight/Height^2 [kg/m^2])	24.2575	3.1979	24.4138	3.1589	24.0829	3.2326
Frequency of dining out (times a week)	1.0288	3.2691	1.3586	3.5335	0.6601	2.9022
Sedentary time (hours a week)	24.6476	14.9353	25.6552	17.7788	23.5215	10.8063
Psychological distress level (Range: 1–4*)	1.2086	0.2339	1.2176	0.2577	1.1984	0.2035
Type 2 diabetes[a] (Yes = 1, 0 Otherwise)	0.0624	0.2419	0.0842	0.2777	0.0381	0.1915
Hyperlipidemia[b] (Yes = 1, 0 Otherwise)	0.0611	0.2395	0.0873	0.2824	0.0317	0.1752
Hypertension[c] (Yes = 1, 0 Otherwise)	0.0597	0.2370	0.0803	0.2718	0.0367	0.1880
Observations	5,944		3,137		2,807	

*Psychological distress level questionnaire referred to relevant studies (26, 62). We took the average value of the nine related questions (Supplementary material). [a]Defined as fasting plasma glucose 7.0 mmol/L or 2-h postprandial plasma glucose 11.1 mmol/L referring to World Health Organization (WHO). [b]Defined by the US National Cholesterol Education Program (NCEP). [c]Defined as mean systolic blood pressure (SBP) 140 mmHg and/or mean diastolic blood pressure (DBP) 90 mmHg referring to WHO.

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TABLE 2 The association of urban living with chronic diseases.

Variables	VIF†	Type 2 diabetes	Hyperlipidemia	Hypertension
		Coefficient (standard error)	Coefficient (standard error)	Coefficient (standard error)
Residence location	1.03	0.8148*** (0.1162)	1.1550*** (0.1264)	0.7498*** (0.1240)
Age	1.05	0.0177*** (0.0058)	0.0085* (0.0044)	0.0660*** (0.0063)
Sex	1.42	−0.0244 (0.1228)	−0.1863 (0.1352)	0.1634 (0.1311)
Marital status	1.03	0.0307 (0.1484)	−0.1065 (0.1510)	0.1697 (0.1583)
Employment status	1.11	−0.5067*** (0.1202)	−0.0188 (0.1095)	−0.0667 (0.1317)
Cigarette smoking	1.36	−0.0807 (0.1372)	0.0279 (0.1811)	−0.0310 (0.1362)
Observations		6408	6408	6408
Prob > chi^2		0.0000	0.0000	0.0000

Robust standard errors in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. †Variance inflation factors (VIF) were examined for each variable to exclude the problem of multicollinearity (range: 1–1.5).

TABLE 3 Potential mediators of urban living on chronic diseases.

Variables	Type 2 diabetes	Hyperlipidemia	Hypertension
	Coefficient (standard error)	Coefficient (standard error)	Coefficient (standard error)
BMI	0.1042*** (0.0163)	0.1617*** (0.0162)	0.1076*** (0.0169)
Frequency of dining out	0.0420** (0.0175)	0.0311** (0.0148)	0.0478*** (0.0175)
Sedentary time	0.0103* (0.0054)	0.0147*** (0.0053)	0.0090 (0.0056)
Psychological distress level	0.4881** (0.1965)	0.7084*** (0.1735)	0.5154*** (0.1975)
Residence location	0.6852*** (0.1235)	0.9631*** (0.1295)	0.6684*** (0.1263)
Age	0.0699*** (0.0064)	0.0408*** (0.0065)	0.0693*** (0.0065)
Sex	0.1793 (0.1288)	−0.0349 (0.1360)	0.1898 (0.1322)
Marital status	0.3034* (0.1615)	0.0723 (0.1635)	0.2218 (0.1614)
Employment status	−0.0979 (0.1355)	0.2135 (0.1339)	−0.1283 (0.1385)
Cigarette smoking	−0.0223 (0.1312)	0.0867 (0.1438)	−0.0108 (0.1325)
Observations	5,944	5,944	5,944
Prob > chi^2	0.0000	0.0000	0.0000

Robust standard errors in parentheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

TABLE 4 Robustness check supporting baseline results using the method of key variable replacement.

Variables	Type 2 diabetes	Hyperlipidemia	Hypertension
	Coefficient (standard error)	Coefficient (standard error)	Coefficient (standard error)
Waist circumference	0.0495*** (0.0065)	0.0713*** (0.0065)	0.0521*** (0.0067)
Frequency of dining out	0.0373** (0.0177)	0.0254* (0.0148)	0.0428** (0.0178)
Sedentary time	0.0103* (0.0054)	0.0145*** (0.0053)	0.0090 (0.0056)
Psychological distress level	0.4760** (0.1960)	0.6984*** (0.1695)	0.5032** (0.1971)
Residence location	0.6359*** (0.1239)	0.8924*** (0.1298)	0.6164*** (0.1267)
Age	0.0632*** (0.0064)	0.0315*** (0.0065)	0.0623*** (0.0066)
Sex	0.3408*** (0.1306)	0.2273* (0.1354)	0.3589*** (0.1337)
Marital status	0.3246** (0.1627)	0.0997 (0.1648)	0.2437 (0.1626)
Employment status	−0.0985 (0.1364)	0.2143 (0.1350)	−0.1290 (0.1395)
Cigarette smoking	−0.0227 (0.1263)	0.0762 (0.1344)	−0.0111 (0.1272)
Observations	5,943	5,943	5,943
Prob > chi^2	0.0000	0.0000	0.0000

Robust standard errors in parentheses; $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

TABLE 5 Results based on the 2021 follow-up survey.

Variables	Type 2 diabetes	Coronary heart disease	Cancer
	Coefficient (standard error)	Coefficient (standard error)	Coefficient (standard error)
Residence location	0.6440*** (0.1037)	0.4772*** (0.1383)	0.3969*** (0.1459)
Age	0.0140*** (0.0047)	0.0249*** (0.0087)	0.0192*** (0.0069)
Sex	−0.0830 (0.1147)	−0.2901* (0.1495)	0.5858*** (0.1614)
Marital status	0.1233 (0.1432)	0.1249 (0.1955)	0.2792 (0.2239)
Employment status	−0.4035*** (0.1033)	−0.5779*** (0.1592)	−0.1909 (0.1620)
Cigarette smoking	−0.2352 (0.1434)	−0.1516 (0.1719)	0.1356 (0.0831)
Observations	6,083	6,083	6,083
Prob > chi^2	0.0000	0.0000	0.0000

Robust standard errors in parentheses; $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

BMI, also had a significant positive effect on the prevalence of type 2 diabetes, hyperlipidemia, and hypertension.

Comparative analysis

To analyze trend in the impact of urban development, we supplemented a follow-up survey in 2021. In this survey, telephone interviews, in combination with local medical databases, were used to extend the range of chronic diseases surveyed to include coronary heart disease, and cancer, which are consequential contributors to the burden in older people in LMICs (39, 40). Referring to classification on chronic diseases from literature, coronary heart disease belongs to cardiovascular diseases broad category (41). Investigation of coronary heart disease can be valid complement in addition to hypertension, which is also subcategory of cardiovascular diseases and have been analyzed in the baseline results. Identically, cancer is another representative broad category of chronic diseases supplemented in our follow-up surveys (41). Results of the follow-up surveys are presented in Table 5.

A longitudinal comparison of the regression results for the two cross-sectional datasets revealed a 20.96% decrease in the coefficient of living in urban areas for type 2 diabetes (Cr = 0.6440, $p < 0.01$). One potential reason is that enhancements in healthcare prevention and treatment systems weaken the impact of urban lifestyles on the prevalence of chronic diseases (42, 43). At this stage, China tends to be defined more as one of the upper middle-income countries seeking to move toward higher income status rather than "emerging economies" (44). Compared with 2001–2010, the number of local health facilities, medical staff, and medical beds per 1,000 people increased by 40.38%, 75.15%, and 93.02%, respectively, from 2011 to 2020 (45). Specifically, urban-rural differences in the utilization of preventive health services may amplify this weakening trend; the main factors contributing to this phenomenon are differences in family income, education, and rate of disease awareness (46).

Coronary heart disease and cancer were chosen for the cross-comparison to represent chronic diseases indirectly associated with living in urban areas and with higher heterogeneity, uncertainty, and diversity of pathogenesis (47). The results showed an association between coronary heart disease and urban living (Cr = 0.4772, $p < 0.01$), but the degree was lower than that of type 2 diabetes. Likewise, the effect of living in urban areas on hyperlipidemia or type 2 diabetes (both are metabolic diseases) (41) was higher than that of hypertension (cardiovascular disease) (41) in the baseline regression. This empirical evidence supports the view that effects of urban living on cardiovascular diseases are partially transmitted through metabolic diseases. A sustained increase in the prevalence rate of diabetes or hyperlipidemia in the population may lead to a concomitant increase in the incidence of cardiovascular diseases (48–50). Similarly, a positive correlation between urban living and cancer can be concluded, in accordance with the literature (51). However, cancer had the lowest level of association (Cr = 0.3969, $p < 0.01$).

Discussion

Our findings in this study again verified the role of the government in preventing negative externality issues in the urban development process, and in building a constantly updated and evolving, targeted, integrated healthcare management (52). Results of this empirical investigation also demonstrate that the high prevalence of chronic diseases due to urban development and aging will continue to put tremendous pressure on the capacity and efficiency of health care services in the coming decades. Accordingly, efforts should be made to improve the incidence of chronic diseases through positive corrections to interrupting the long-term processes that cause chronic diseases at an early stage, including changes in the physical fabric through policy interventions (53), and raising awareness rate and prevention knowledge among the population based on the general increase in the population's education level. A comparative study revealed that associations between health status measures and social determinants of health were largely not supported among rural women, but were for their urban counterparts (54). In this regard, multilevel interventions aimed at eliminating systemic social inequalities regarding access to educational and employment opportunities, welfare coverage, and secure housing would have far-reaching implications in urban development (e.g., homeless assistance programs, income supplements, and refundable tax credits for low-income working individuals) (27).

For the public healthcare sector, more emphasis could be placed on mental health guidance, regular monitoring of the psychological status of residents, and results-oriented integration of monitoring results into the future implementation of healthcare system reform. To promote the development of urban healthcare, equalization in public healthcare is an imperative issue that requires to be recognized. Rural-to-urban migrators with higher needs for health services remain a particular group that should be focused on. The "floating" population is affected by more diversified risk factors of urban living and may not have healthcare coverage equal to urban residents (55). In addition to addressing these health challenges involving disturbing disparities in access to medical services, vaccination coverage, and accident and injury insurance among China's rural-to-urban migrated population, innovation in health policies should also focus on migrants' needs for primary care, preventive health check-ups, and early diagnoses of cancers (20, 56, 57).

The private healthcare sector has become an increasingly important complement to improve the adequacy and equality of China's healthcare system since the healthcare system reform.

However, strict regulation and insufficient risk-management capacity have continued to hamper private sector involvement in health services production and insurance. Data from the China Health and Retirement Longitudinal Study have investigated that although patients with health insurance and higher socio-economic status were more likely to be aware of health service provider's ownership, they preferred public providers over private providers (58). According to our findings, while urban development accelerates the emergence of economies, urban dietary habits and lifestyles have simultaneously brought complex superimposed effects among chronic disease risk factors for modern humans. To meet the enormous pressure in demand for healthcare in cities, a compromise model in which competing private providers are non-negligible participants in the healthcare system, but in which the government intervenes in such a way as to attain both a high degree of healthcare equalization and to avoid the "market failure" in an unregulated private system may be the optimal choice (59).

Increasing incomes and urban development are driving a global dietary transition, with traditional diets being replaced by diets high in refined sugars, fats, oils, and meat. Modern urban diets significantly increase the incidence of chronic diseases such as type 2 diabetes, coronary mortality, and cancer in addition to the higher growth of greenhouse gas emissions than Mediterranean, pescatarian, and vegetarian diets. These trends will be a major contributor to an 80% increase in global agricultural greenhouse gas emissions by 2050, and therefore, implementing solutions that address the strong "diet-environment-health" nexus is a global issue (60). The guidance of a rational diet structure in public health management will subsequently benefit the socio-economical goals of food security, sustainable use of land resources, and ecological protection in 21st century urban planning.

Although living in cities is a global trend and is most prevalent in the LMICs, cities of LMICs are exceptionally ill-prepared for the explosion in urban living (61). Our study provides experiences for LMICs undergoing high-speed economic growth or economic transition that the urban primary healthcare system construction should be the focus of urban welfare system planning. In the future, this will become the solid foundation for releasing the pressure on urban healthcare services brought about by the explosion in urban residents. Further, owing to heterogeneous presentations of chronic diseases among LMICs, a better understanding of the epidemiology is urgently needed to include non-conventional risk factors concerning anxiety disorders, sleep insufficiency, and stress as factors mediating urbanization and chronic diseases (3, 62, 63). As our research has shown, psychological stress may be another necessary concern in addition to income body weight gradients in LMICs' rapid urbanization process (5, 6), whose contribution to the incidence of type 2 diabetes, hyperlipidemia, and hypertension has been proved to be 3.68, 3.38, and 3.79 times higher than nutrition transition, respectively.

This study presents some limitations. Although we compared the variability in the relationship between urban living and typical chronic diseases, future research continues to be required on the mechanisms of effects on cardiovascular diseases and cancer. In addition, factors associated with neighborhood effects including assets value, the number of social security beneficiaries, and social cohesion could extend the study on the incidence of chronic diseases in the context of urban living (17, 21). Another potential study limitation is that the follow-up survey supplemented was still based on cross-sectional data with infrastructural constraints. In the next phase, we will consider a dynamic approach to include more longitudinal information on subjects and systematically classify the relationship between living in urban areas and chronic diseases.

Data availability statement

The datasets presented in this article are not readily available because participants data are used for scientific research only, further requests for data are required to obtain approval from the survey project committee. Requests to access the datasets should be directed to 5134wsl@163.com.

Ethics statement

The studies involving human participants were reviewed and approved by the Research Protection Committee of Wuyishan Municipal Hospital. All participants signed an informed consent form before information collection. The patients/participants provided their written informed consent to participate in this study.

Author contributions

YL: writing and editing of the manuscript. SW: data collection and co-editing of the manuscript. Both authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.1042413/full#supplementary-material

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Community advisory committee as a facilitator of health and wellbeing: A qualitative study in informal settlements in Nairobi, Kenya

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Introduction: A range of community engagement initiatives to advance health and wellbeing are currently taking place in informal settlements in low and middle income countries (LMICs), including community and stakeholder meetings, use of radio, film, TV programs and other information, education and communication materials (IECs) organized by different stakeholders. While these initiatives tend to focus on unidirectional flow of information to communities, the need to incorporate initiatives focusing on bi or multi-directional flow of information have been identified. Despite the extensive body of literature on community engagement, the role of Community Advisory Committees (CACs) in advancing health and wellbeing in informal settlements is still a puzzle, occasioned by considerable ambiguity. A community advisory committee is a dedicated group of volunteers to support health and wellbeing needs of their community using a community approach. Researchers and project implementers work in partnership with CACs to successfully implement their activities within the target community.

Methods: In this paper, using in-depth interviews, we document the roles of CACs in advancing health and wellbeing in Korogocho and Viwandani informal settlements in Nairobi, Kenya.

Results: Study participants described the role of CAC in advancing health and wellbeing through education and awareness creation, advisory roles in research and implementation goals, protecting community interests and acting as gatekeepers and collaborators to community partners. Identified barriers to achieving CAC roles include lack of finance and other field resources, being labeled as organization staff and low involvement by some upcoming and emerging local leaders on issues which involve the CAC constituents. Enablers of CACs in their roles include possession of appropriate skills and values by members; involvement of the community in the selection of members, regular consultative and advisory meetings, representativeness in the composition of CAC membership and knowledge about the community.

Conclusion: We conclude that CACs play key roles in advancing health and wellbeing in informal settlements and that existing CACs mechanisms and operations need to be given due consideration by researchers, project implementers and local authorities right from project conceptualization. CACs need recognition beyond consultations and placations during research and project implementation to a veritable social

structure for community's social viability and survival as well as partners in development for inclusive urbanization process. While CACs have contributed in advancing health and wellbeing in informal settlements, there is need for a long-term strategy to optimize their impact and reduce puzzles around their roles.

KEYWORDS

community advisory committee, health and wellbeing, community advisory board (CAB), informal settlements, qualitative study, community based participatory research

Introduction

Globally, there is a universal agreement that health and wellbeing challenges in informal settlements are unacceptable and require urgent action (1, 2). Cities have unequal outcomes and opportunities because many population groups residing in informal settlements are systematically excluded from participating in health and wellbeing activities, processes and decisions (2, 3). Participation by study communities is important, as growth often occurs so quickly that urban planners do not know the actual population density and needs of residents in the informal settlements (4). A lack of community participation leads to a situation in which public resources fail to reach the vulnerable groups (5, 6), as such most residents of informal settlements face asymmetries in health and wellbeing advancement and opportunities in informal settlements (7). Past approaches toward the health and wellbeing asymmetries in informal settlements were characterized by a combination of patronage and neglect, insecurity and inequity (8). This was accompanied by a blinkered approach to data and knowledge of settlements (6, 9). Past 10 years have witnessed an intense focus on health and wellbeing aspects of land, housing, labor and basic amenities (10, 11). The approaches together accompanied by a denial of residents' participation have created conditions in which the settlements continue to be bundles of exclusions (10). Social exclusion is a determinant of health and wellbeing challenges in Africa's informal settlements, and can be reversed through social participation (12). Promoting social participatory mechanisms in Africa's informal settlements can be an efficient principal formula for advancing health and wellbeing (13). One principle mechanism that produces a relationship between social participation and advanced health and wellbeing is community engagement (8, 14).

Community engagement approaches promotes health and wellbeing by ensuring the involvement of communities as true partners in all phases of community activities based on key principles that include, amongst others, the recognition of the community as a unit, the use of community structures and strengths, and sharing access to information and knowledge with all partners (15, 16). However, community engagement process in Kenya's informal settlements does not always advance health and wellbeing, as there is minimal active engagement of community members as partners in all aspects of community activities (17). When partners are fully engaged, they contribute their expertise in understanding a given phenomenon and integrate rich local knowledge gained with action for advanced health and wellbeing related benefits to communities (14, 18). Over the last 15 years, there has been growing attention on the principle of establishing partnerships through community advisory committees (CACs) for active community engagement and success of project and research activities (18, 19). CACs are a dedicated group of volunteers who support health and wellbeing needs of their community using a community approach. Researchers and project implementers work with CACs for successful implementation of their activities in the best interest of the target community. The committee comprises representatives from community members, government authorities and service providers. The representatives jointly serve as liaison between the partners and the community, thus, curbing a one-way flow of information from the partners to communities (20, 21). Despite the extensive body of literature on community engagement, the role of CACs in advancing health and wellbeing in informal settlements is still a puzzle (18, 21), occasioned by considerable ambiguity (15).

It was with this background that we sought to deeply understand the roles of CACs as established in the two informal settlements where the African Population and Health Research Center (APHRC) runs the Nairobi Urban Health and Demographic Surveillance System (NUHDSS) in promoting health and wellbeing over time. NUHDSS

Abbreviations: APHRC, African Population and Health Research Center; CAC, community advisory committee; CBOs, community based organizations; CHV, community health volunteer; ESRC, Ethics & Scientific Review Committee; FGDs, focus group discussions; IDIs, in depth interviews; IECs, education and communication materials; LMICs, low and middle income countries; LSTM, liverpool school of tropical medicine; NACOSTI, National Commission for Science, Technology and Innovation; NUHDSS, Nairobi Urban Health and Demographic Surveillance System.

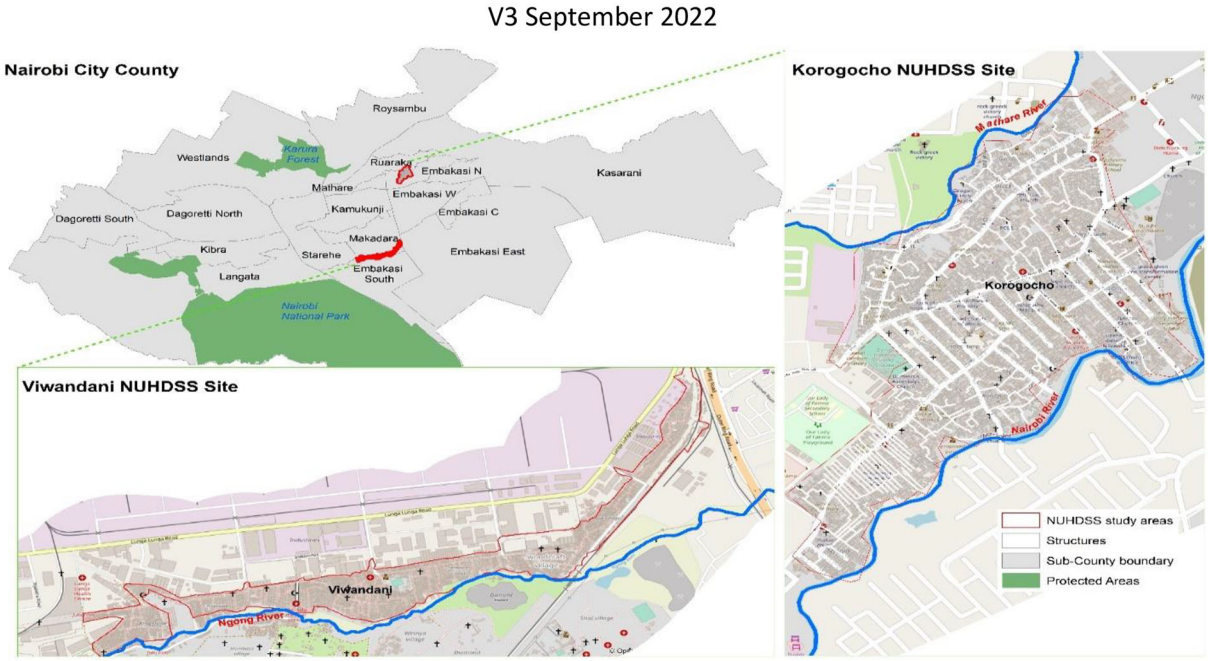

FIGURE 1
Study sites (Source, authors, 2020).

was established by APHRC in 2002 to provide a platform for investigating the long-term social, economic and health consequences of urban slum residence, and to serve as a primary research tool for intervention and impact evaluation studies focusing on the needs of the urban poor (22). In addition to the routine data, NUHDSS has provided a robust platform for nesting several studies examining health and wellbeing challenges of rapid urbanization in Africa. The conceptualization of CAC began in 2012 as part of how the APHRC would work collaboratively with the study communities to contribute to research and implementation projects. Overtime, the CACs has been beneficial to researchers and implementers (i.e., from within and outside APHRC) while engaging with the study communities. Similarly, Accountability and Responsiveness in Informal Settlement (ARISE) project requires an active participation of the study communities (23) in evidence generation as co-researchers and in co-creation of solutions to community challenges. As a result, the project team, at its inception, identified the need to assess and document the roles of CACs so as to facilitate community engagement. This becomes important as diverse influences have resulted in considerable ambiguity about the current roles of CACs (20). Consequently, this paper seeks to address the ambiguity and knowledge gap, by documenting the roles of CACs in advancing health and wellbeing in Korogocho and Viwandani informal settlements in Nairobi, Kenya.

Methodology

Study design

> This was a qualitative study using in-depth interviews (IDIs). As an exploratory and descriptive study, IDIs have the potential to generate more insightful responses from those who know about the community. With none of the potential distractions or peer-pressure dynamics that can sometimes emerge in focus groups, IDIs provide insightful and possibilities for high valuable findings, with interviewers having greater opportunities to ask follow-up questions, probe for additional information, and circle back to key questions later on in the interview, which will ultimately generate a rich understanding of attitudes, perceptions, and motivations (24) in our case on the roles of CAC in both communities.

Study setting

The study was conducted in Korogocho and Viwandani informal settlements in Nairobi (Figure 1), in the areas covered by NUHDSS initiated in 2002 by the APHRC (22). Korogocho has a stable and settled population and residents have lived in the area for many years (25), while Viwandani

is located next to an industrial area with many highly mobile population who work or seek jobs in the industrial area (25). The community advisory committee working in each of the NUHDSS sites is composed of approximately 13 members, who were elected by respective constituent groups that they represent. The members represent various constituencies in the community, government, local leaders/village elders, the youth, women, older persons, school administrators, healthcare providers, Faith-based organizations/Community based organizations/Local Non-governmental organizations (FBOs/CBOs/local NGOs), Community Health Volunteers (CHVs), media/education and entertainment organizations, religious groups and people living with disabilities.

Target population, sampling and sample size

The population of interest were CAC members, community members, community-based organizations (CBOs), Researchers and Implementers and Community Liaison persons. The population of interest ought to have interacted or heard about CAC. The study population allowed for data triangulation and were drawn from APHRC, the organization that facilitated the formation of the two CACs in Korogocho and Viwandani informal settlements in Nairobi, Kenya. Data was collected from all 13 CAC members in each study site as they represent different sectors/constituencies in the community. Data collection tools were also administered to two Community liaisons and six Researchers and implementers who worked closely with CAC in the study sites. Lastly, the tools were administered to five community members and four CBOs in each study site, who were selected if they had interacted or knew about CACs.

Data collection process and data quality

We collected data from 19/05/2020 to 14/06/2020. Research Assistants were selected if they had been endorsed by community leaders to be trusted community residents in the study sites and by the researchers if they generally had at least 5 years of experience in qualitative research. Research Assistants were trained for 5 days on the aims of the study, data collection process, data collection tools, and research ethics. Pretesting was done with one former CAC member and two community members to establish the length of the interviews and to ensure the language could be understood by the study participants. Data was collected through In-depth Interviews (IDIs), using an IDI guide which had questions on the role of CAC in advancing health and wellbeing. The interviews were conducted in English and Swahili and were held through a mix of face-to-face and phone interviews at a quiet location convenient to the participants which were mainly at their homes and sometimes remotely through phone calls at the convenience of the study participants. The interviews were recorded using a digital recorder and backed up with handwritten notes. These interviews lasted for ∼1 h.

We reviewed all audio files to ensure completeness and depth of the interviews, and provided feedback to the field team at the end of each working day. Debriefing sessions were also held at the end of each working day to highlight the key emerging themes, review probing techniques, and assess progress.

Data analysis

Transcripts were imported into NVivo 12 software (QSR International, Australia) for coding and analysis. NVivo is a qualitative data management software that can be shared and worked on in groups and facilitate thinking, linking, writing, modeling and graphing in ways that go beyond a simple dependence on coding (26). We used a framework analysis (27). Framework analysis is adopted for research that has specific questions, a pre-designed sample and priory issues (27). The first step of framework analysis was listening to the recordings to familiarize the researchers with the information related to role of CACs. To ensure reliability, two researchers (an experienced qualitative researcher with community engagement and an anthropologist) and five co-researchers, who collected the data participated in the development of a coding framework by reading the outputs imported in NVivo 12 software independently to establish an inter-coder agreement. Once the initial coding framework was completed, the team met to discuss the themes generated and to reach an agreement on themes. Two researchers proceeded with coding, charting, mapping and interpretation of transcripts. Similar emerging issues were combined into single categories through consensus discussions.

Ethical considerations

The study was approved by the AMREF Health Africa's Ethics & Scientific Review Committee (ESRC), REF: AMREF-ESRC P747/2020. We also obtained approvals from National Commission for Science, Technology and Innovation (NACOSTI), REF: NACOSTI/P/20/7726. Approval was also obtained from the Liverpool School of Tropical Medicine (LSTM) and the African Population and Health Research Center (APHRC) internal ethical review committees. All participants provided informed written consent before participating in an interview. The interviews were conducted in quiet spaces for privacy, confidentiality and for the quality of the audio files. All participants provided informed written consent before participating in an interview, and were free to drop from the interview at any point in time. The interviews discussions

were anticipated from the onset to take ∼ 45–60 min, as such we compensated the study participants for their time.

Results

Demographic characteristics of the study participants

We present the demographic information of the study participants by category and; by gender in Table 1. These demographics were largely similar in Korogocho and Viwandani.

We present our findings following the core theme of the role of CAC in advancing health and wellbeing, and emerging themes of enabling factors and barriers to achieving the roles. The themes and corresponding subthemes that emerged from our analysis are summarized in Table 2 that follows.

TABLE 1 Demographic characteristics.

Participant category	Gender		Total
	Males	Females	
CAC			
Community health volunteer (CHV)	1	1	2
Older persons representative	1	1	2
Women representative	1	1	2
Community members	2	3	5
Community-based organizations CBOs	2	2	4
Researchers	X	Y	3
Implementers	X	Y	3
Community liason	1	1	2
Total	X	Y	52

TABLE 2 Study themes and subthemes.

Themes	Subthemes
Role of CACs in advancing health and wellbeing	• Education and awareness creation • Advisory roles • Advance research and implementation goals • Protecting community interests • Gatekeepers and partners
Enabling factors in achieving the role of CACs	• Community values • Intrapersonal and interpersonal skills acceptable to the community • Knowledgeable about the community • Governance structure of CAC
Barriers to achieving the role of CACs	• Lack of finance and other field resources • Low empowerment to perform duties and being labeled as organization staff • Limited time allocated for meetings • Challenging emotional reports

Themes 1: Role of CACs in advancing health and wellbeing

Study participants described that the roles of CACs in advancing health and wellbeing included education and creation of awareness, advisory role, advancing research and implementation goals, protecting the interest of the community and acting as gatekeepers. The roles were interconnected, for example in the process of creating awareness, CAC could simultaneously be protecting the interest of the community.

Education and awareness creation

Study participants described CACs as playing a key role in educating the community on health and wellbeing issues, through consistently creating awareness in the community on the same. The education and awareness creation was linked to their attempts to narrow service delivery gaps in water, sanitation, hygiene, use of face masks in the phase of the Coronavirus disease (COVID-19) pandemic, general cleanliness, maternal and; child health and security.

> *"We educate people… I have to talk to every person I meet and tell them that they must boil or treat water before drinking… we ask them to clean their toilets and use the toilets accordingly because if that is not done, people become sickly."* (IDI, CAC, Korogocho, Female).

To reach a vast population, CAC members utilized existing social structures and networks. These included community meetings, social gatherings, support group meetings, and public transportation.

> *"During church meetings and other social gatherings, we educate the community on the importance of hand hygiene, drinking of clean water and on the importance of NHIF {medical insurance} cards… We create awareness on wearing masks, even while on public transport or in other forums"* (IDI, CAC, Korogocho, Female).

Study participants described how CAC empowered the community on how to ensure that the researchers/partners gives back to the community. While creating awareness, CAC was also described in terms of relaying the right information to the community in the right way.

> *"We educate people to ensure that schools have kept the environment clean, children are not harmed, and the school environment is good for the children; we bring good coordination between the parents, teachers and the children… We {CAC} ensure the information needed to reach the community gets to the community as needed and in good time"* (IDI, CAC, Viwandani, Male).

Advisory roles

Study participants agreed that CACs play health and wellbeing advisory roles to stakeholders in the community. The advisory roles described ranged from the inception to completion period of a project or program. Respondents stated that while implementers/researchers were giving input during planning and protocol development, the views of lay community members on projects ought to be respected. In their advisory role, CACs allowed for debates with the implementers/researchers for mutual agreement with the community thus advancing health and wellbeing.

> *"We advise partners; researchers, implementers or even community members from the beginning to the end… then depending on their capability, they can follow our advice on when, where and how a program or project could be conducted. If they are not able to follow our advice, we discuss it further and give room for debate. We cannot send anyone away"* (IDI, CAC, Korogocho, Male).

Researchers also confirmed what the CAC described on how they play a great advisory role:

> *"We always seek advice from CAC before doing any community activity including research… sometimes in the course of a one-year project, we meet with them up to 6 times for advice on how to conduct research or implementation activities at the community and who to involve in implement projects and what would be the best time to conduct research and implementation activities"* (IDI, Researcher, Male).

The advisory roles were described to go beyond the research and implementation team to the other stakeholders in the community including community members, CBOs and service providers. As such, CAC was acknowledged by the community and community-based organizations to be playing an important role in advancing health and wellbeing.

> *"When we suspect that the vulnerable people in the community like the persons with disability are mistreated by some partners in the activities they do at the community, we usually consult and seek advice from CAC… We do interact a lot and I think the administration relies a lot on us for our advice on community issues, more so to ensure no one is discriminated against by anyone"* (IDI, Community member, Korogocho, Female).
>
> *"We {CBOs} normally have an interactive discussion with our partners about specific health and wellbeing services, we usually invite some CAC members for advice on how to bring them closer to the community"* (IDI, CBO, Viwandani, Male).

Advance research and implementation goals

Study participants described how advancing research and implementation goals was a primary role of the CACs in their attempt to advance health and wellbeing. The participants consistently stated the roles of CAC included identification of household structures and study participants for a research or an implementation program. Participants' interpretation of these roles included examining issues of consent and confidentiality, coercion, support, community involvement and acting as liaison in research and project implementation.

> *"We ensure that researchers and implementers observe privacy and do not disclose personal issues to others without the owner of information being notified. We also ensure that the community is well informed and involved without discrimination by anyone and that no community member is forced by implementers or researchers to be part of a program"* (IDI, CAC, Korogocho, Female).

One of the researchers said the following about the CAC's insights about the study communities and how these insights help inform the researchers' understanding in the process of implementing their studies:

> *"They [CAC] know their communities better than we do. They work with us in implementing our studies and to help us understand the community"* (KII, Researcher, Male).

While advancing research and implementation goals, CAC was also described as playing a two-way mutually informative liaison role between the community and the researchers and project implementers during the research and project implementation phase. For example, study participants described how the community members could easily access CAC to relay information to researchers and implementers and on the other hand, researchers and implementers could easily access the CAC to relay information to the community during a project implementation phase. As such, researches, implementers and community members trusted CACs with problem resolution.

> *"CAC have a great understanding of the community. If there are problems with stakeholders in the community, CAC assists with resolving them."* IDI, CAC, Viwandani, Female).
>
> *"The role of CAC is to be a link between project implementers or researchers and the communities and to feedback to the researchers and implementers on issues"* (KII, Community Liason, Female).

Protecting community interests

Our study revealed how CAC members protected community interests by representing the community and providing substantive input into a project implemented at the community. As such, study participants described how CAC represent the community in resolving community issues related to security, education, sanitation, water and health among others.

> *"We are always at the forefront in everything that happens here in the community in the attempt to ensure that the community benefits. We do this by providing input into different projects. We do help both the researchers and the community. We discuss many issues in our meetings for the benefit of the community"* (IDI, CAC, Korogocho, Male).

Participants described CAC as an eye on what happens in the community, while protecting interest of the community. There were other discussions on the role played by CAC in assessing and monitoring the integrity of community activities and CBOs for the benefit of the community as a whole.

> *"When research is being conducted, we are the eyes… If one wants to sponsor matters like health or water or sanitation, as the eyes of the community, we allow them to proceed if they are beneficial to the community… We assess the research and implementation projects to establish if they have truly come to help people in the community as they purport."* (IDI, CAC, Viwandani, Male).

Researchers, Community members and CBOs description of how the role of CACs concurred with the roles in protecting interests mentioned by the CAC.

> *"The primary role of CAC is to ensure there is community involvement on project activities for the benefit of the community"* (IDI, Researcher, Female).

Gatekeepers and partners

Study participants described how CAC members acted as gatekeepers and partners to stakeholders from outside the community. Before any individual gets to implement a project in the community, CAC members were involved. During project implementation, the CAC also acted as partners to the stakeholders and contributed to project activities.

> *"We ensure that no one gets to the community without going through us… we act like gatekeepers and partners once the visitors or outsiders are in the community"* (IDI, CAC, Korogocho, Female).

Community members, researchers and CBOs also described CAC as gatekeepers, peacekeepers, and community representatives, who acted as partners for improved health and wellbeing and community functioning.

> *"They {CAC} are like the gatekeepers in the community… CAC seek ways to sort the issues at the community for everyone"* (IDI, CBO, Korogocho, Female). *"CAC members are representing community for health and wellbeing equity in the community"* (IDI, Researcher, Male).

> *"To the community, CAC is a peacekeepers; mediates for peace between community and new stakeholders… We {community} understand CAC members as people who represent us in many forums"* (IDI, Viwandani, Community member, Male).

Theme 2: Enabling factors in achieving the role of CACs

Study participants described enabling factors for the role of CAC and it included possession of community values, intrapersonal and interpersonal skills acceptable to the community, being knowledgeable about the community, and good governance structure of CACs.

Community values

Study participants described how community values enhanced the role of CAC. The CAC members had the following values acceptable by community, love for community, patience and being role models. The values enhanced trust and acceptance of the committee by the wider community. This promoted good relationships with people in the community and advanced health and wellbeing.

> *"CAC members are volunteers and love the community… We are not paid a salary but we love our community. How well you show love and are patient to people is important because it promotes trust and acceptance by the community."* (IDI, CAC, Viwandani, Female).
>
> *"You must be a good role model, and active in the community… I usually tell the landlord and other tenants, 'Before one rent any of these houses, you must find out where he/she is coming from… and if you can't talk to that new tenant yourselves, please look for me so that I can come and find out where one is coming from'. This has really helped in promoting trust"* (IDI, CAC, Korogocho, Male).

Intrapersonal and interpersonal skills acceptable to the community

Study participants described how interpersonal and intrapersonal skills were enablers of the roles of CACs. The skills included flexibility, teamwork, leadership and passion. The skills enhanced the role of CAC members in their attempt to advance health and wellbeing in the community.

> *"You must be flexible, team player and able to interact well for you to serve the role of CAC effectively… one who is disciplined should be a CAC member"* (IDI, Community member, Korogocho, Male).
>
> *"Someone should have leadership skills and not be greedy but they should be looking for the interest of the*

> *community. For example, a CAC woman representative must be passionate about women and have women issue at heart."* (IDI, CAC, Viwandani, Female).

Knowledgeable about the community

One ought to be knowledgeable about the community and the community constituency they represent. Study participants described how being knowledgeable enabled CAC members to perform their roles effectively.

> *"A knowledgeable persons to improve a community are chosen to be in the CAC… If one has good community knowledge, they can be effective… I may be well educated but if I do not understand the problems of the community then I cannot serve well in the CAC"* (IDI, CAC, Viwandani, Male).

Governance structure of CAC

CACs governance structure provided for the community, through the various community constituencies to each build consensus on who may best represent their interest from amongst a set of volunteers from their own constituency. Furthermore, it allows for the CAC members to on their own agree on and set their routine consultative and advisory meetings within the year. As such, CAC members were seconded by their respective constituencies on the basis of their capacity to effectively represent their constituency, which is dependent on the residency or working in the informal settlement and knowledge of the issues that are important to their constituency and knowledge of the informal settlement.

> *"Members are chosen by the community and in particular the members of a constituency. One of the requirements is that you must come from the community, the second thing you must have been working in the community as well as part of the role you are chosen, for example, a representative of health should be working in a health sector/role"* (IDI, CAC Korogocho, Male).

Study participants emphasized how meetings held regularly enhanced the role of CAC. Occasionally, service providers were invited to CAC meetings for debate on a common topic. This allowed for demanding equitable service provision on behalf of the community and their constituency.

> *"There are times when we are brought together with education or hospital owners. There we brig the accusations before them. We tell them, 'At your place, there was a client who was treated unfairly' this is actually how the service providers are compelled to offer the best so that they are not embarrassed in other meeting"* (IDI, CAC, Korogocho, Male).

CAC governance structure had guidelines, as such there were agreed measures and principles for ensuring adherence by the members to keep the CAC functioning. For example, CAC members who consecutively miss routine meetings without apologies would be discontinued from membership and the affected constituencies advised to provide replacements. CAC was described to be non-political but goal oriented.

> *"We usually discontinue members who miss out on meetings without apologies… It is a committee that is not political… it is a committee that has principles and is focus oriented…"* (IDI, CAC, Viwandani, Female).

Notably, there were no reported cases of disagreements amongst CAC members as the CAC structure ensured that a member first and foremost represents the voice of their constituency, and not self. For example, a woman representative would be keen to represent issues of women in terms of how the proposed research topic or project activity would affect or impact them.

> *"We have not had any conflicts so far because we represent different and separate groups. In the event that there is a conflict, we usually select a team lead and so he/she will lead in the resolution"* (IDI, CAC, Viwandani, Female).

Study participants described how CAC governance had a structured leadership that could help address any potential conflicts. For example, the leadership is composed of a CAC patron and the Area Chief, who is the representative of the National Government in Kenya and who sits in all the CAC meetings to help moderate conflict situations alongside the CAC Chairperson, usually elected by the CAC members as their leader.

> "*CAC composition has got a clear leadership that enables prevention of conflicts. There is a patron for CAC, Area Chief and village heads, who oversee resolution of conflicts, in case it arise. However, we have had no conflict because we are interested in the community benefiting*" (IDI, CAC, Korogocho, Male).

Theme 3: Barriers to achieving the role of CACs

There were barriers to CAC effective operations reported which included: lack of finance and other field resources, being labeled as organization staff, low involvement by some local leaders on issues which involve their respective constituency and less time allocated for meetings.

Lack of finance and other field resources

CAC members stated that they did not have a budget allocation to support their roles in the community. The members did not have facilitation for field resources and communication,

which made it extremely challenging to pass on information when needed.

> *"At times during the rainy season, when we want to go on the ground, the lack of things like boots are a problem… We also need things like, bags and umbrellas."* (IDI, CAC, Korogocho, Male).
>
> "*Some things happen in the community that needs our service and our support but we do not have a facilitation for transport and communication*" (IDI, CAC, Viwandani, Female).

Low empowerment to perform duties and being labeled as organization staff

Despite that collective awareness creation and advocacy on CACs at the community, CAC members described how they were labeled as organization staff by the community, which made some of the members to feel less empowered in performing some tasks because community members expected too much from them. The labeling also sometimes made them felt left out from other important activities in the community that concerns their constituency, more so by upcoming influential groups at the community.

> *"Some community members label us as staff of organizations who come to the community, so they expect much help than we can offer… We are not empowered. We cannot go ahead and do things out of our own volition. I represent the community but when it comes to issues that concern me and the constituency, I am not always involved by some local influential leaders…"*(IDI, CAC, Viwandani, Male).

Limited time allocated for meetings

CAC members thought that the frequency and time allocated for meetings in many instances did not allow in-depth assessment of issues.

> "*We hold few meetings that last for an average of 2-3 hours only... Researchers and implementers have many other things to do and so they only allocate less time*" (IDI, CAC, Viwandani, Female).

Challenging emotional reports

Furthermore, CAC members mentioned that listening to issues from community members sometimes affected them emotionally, especially since they had a role to provide support to the person confiding in them.

> *"Some issues brought to me by the community are challenging and you can feel like crying, but then you are supposed to be strong to keep the discussions"* (IDI, CAC, Korogocho, Female).

Discussion

Our findings contribute to the literature on the role of dimensions of local social structures like CACs in advancing the viability of urban living in the face of increasing urbanization of poverty, especially among residents in informal settlements, building on partnership approaches in community engagement in promoting health and wellbeing. This is similar to other studies depicting the basis of CACs underpinned in the community development and public health needs to consistently and constantly engage the community (14). Our findings showed that turning the tide is not only possible, but it is also imperative, as many individuals working in informal settlements embraced the roles of CACs in advancing health and wellbeing. We describe how advancing health and wellbeing by reaching the poorest and most marginalized groups, requires strong community ownership of the value and purpose through for example working with CACs in informal settlements. We find specifically that CACs advanced health and wellbeing through education and awareness creation, advancing research and project implementation goals, advisory role, protecting interest of community and acting as partners and gatekeepers. These findings are consistent with other studies that have described how there is a clear urgency to advocate for reduced health and wellbeing challenges in informal settlements through community engagement (18). This follows an analysis of current trends, which provides evidence of persistent health and wellbeing challenges, yet, there is optimism and always a way forward through community adaptive mechanisms (8). While our findings do not show any reports of how differences amongst the CAC members could impede research or project implementation within the community, we note that the CAC governance structure provided for a leadership that could help address such differences before they get out of hand. For example, there is the CAC patron, the Area Chief, who is the representative of the National Government in Kenya and who sits in all the CAC meetings to help moderate in such situations alongside the CAC Chairperson, usually elected by the CAC members as their leader.

Noted enabling factors for the roles of CACs included possession of community values, intrapersonal and interpersonal skills acceptable to the community, being knowledgeable about the community, and good governance structures of CACs. The governance structure allowed for the involvement of the community in the selection of CAC members; convening consultative and advisory meetings, representative composition of members and a great knowledge of the community by CAC members. These factors enhanced the level of trust and acceptance of the committee by the wider community. This relates to other studies and experiences by CACs in South Africa (28) and Zimbabwe (19), describing enabling factors as involving the community, knowledge and understanding of the community and good CAC engagement

structures (18). CAC members were volunteers that is, they offered themselves to represent their constituencies without any wages except a small non-compulsory facilitative allowance to partly enable them to discharge their various roles for the benefit of community, and as such motivation strategies are important for the CAC members to continue volunteering. Strategies that instill a sense of empowerment and capacity building are essential to promote the role of CAC members. This implies that there is a need to adopt recognition of CAC members' contributions of time, resources, and expertise, through some type of compensation and acknowledgment (29, 30). Many partnerships do not have the means to provide monetary remuneration (18, 19, 31). As such, partners, including implementers and researchers and NGOs should identify other means to promote CAC membership retention and ensuring that the benefits of membership outweigh the costs. Such strategies may include partners facilitating adequate orientation and training of new members, providing opportunities for social interaction, adequate access to information and resources, influence in decision making, and recognition for contributions. Inexpensive strategies to recognize members' contributions could include dinner parties, awards, certification, positive recommendation letters, and recognition in local media. Even though the provision of stipends or honoraria by the researchers/implementers in meetings (30) can serve as a form of recognition for the contribution of the CAC member, in resource limited communities even providing relatively small amounts of money in the form of transport reimbursements does have the potential for undue influence (19), as such it is important for partners to agree on an appropriate amount with the community and document an ideal compensation to be adhered to by every partner.

Our study showed that CACs played some roles that advanced health and wellbeing. However, engaging committees was described as time-consuming, as such meetings were felt not to exhaustively discuss all issues intended to be discussed by the CAC. This observation is consistent with other studies describing how time consideration for a meeting often go beyond what is usually perceived as directly related to the task/purpose of the research or implementation, to include providing transportation, technical assistance, and participating in community events (32, 33). This is important in addressing the opportunity costs of CACs membership and participation in its activities. Besides, there were challenges related to competing demands and financial and field resources, low empowerment to perform duties and being labeled as organization staff and challenging emotional reports. Other studies described how financial, political and institutional pressures make it difficult for individuals within these organizations to devote the requisite time, finance and energy to a particular community-based endeavor (34–36). Lack of financial, political and institutionalization could be the reason why the CACs faced the challenges. This implies that some CAC members would end up being less engaged at the committee during some seasons. This was supported by evidence from other studies describing how challenges faced by CAC members, led to some of them not being fully engaged when needed (21, 37–39). The challenging concerns do not negate the positive effects of the role of CACs but need identifying at an early stage during the planning of community engagement.

Limitations of the study

Our study is not without limitations. The study was carried out during the peak of Covid-19 outbreak. However, we observed all the Covid-19 public health measures and successfully conducted the study. The study was also conducted in two informal settlements in Nairobi, Kenya. Korogocho study site represents settlements that are stable with a settled population, where residents have lived in an area for many years. Viwandani on the other hand represents settlements with many highly mobile population. The lessons may be transferable to other informal settlements, even outside of Kenya because of the diversity in informal settlements selected and groups and stakeholders represented.

Conclusion

The past several decades have seen a resurgence of interest in partnership and participatory approaches to research and project implementation, with an emphasis on community engagement approaches that are beneficial to the communities. CACs provide a social infrastructure for community members to voice concerns and priorities that otherwise might not enter into the researchers' and program implementers' agenda and advise about suitable processes that are respectful of and acceptable to the community. It is fundamentally important that the CAC is able to carry out its functions independently of the research and implementation teams in order to protect the community from any unethical practices. A factor that has the potential to negatively influence this independence is the mechanisms for compensating CAC members for their time and providing resources for their functioning. As such, there is a need for researchers' and implementers' to adopt a long-term strategy to optimize the overall impact of CAC for the benefit of study communities.

We recommend that community engagement mechanisms like CACs should be of consideration to every research and implementation team during the conceptualization of a project, and not just for consultation and placation. This is because most people in participating communities beyond their low socioeconomic status, have a better understanding of their community needs as well as social norms than partners do. If the CAC initiative is strengthened and valued by community stakeholders, it will contribute to advanced health and wellbeing and lessen or do away with project/research

implementation challenges in informal settlements in Kenya and beyond. There is therefore a need to adopt the recognition of CAC members' contributions of time, resources, and expertise, through some type of compensation. These calls for researchers and implementers to adopt innovative strategies to recognize members' contributions. In addition, it is important to identify other means to promote CACs' membership retention and ensuring that the benefits of membership outweigh the opportunity costs. Such approaches may include but not limited to adequate orientation and training of new members, creating opportunities for social interaction and participation, adequate access to information and resources, influence in decision making, and recognition of contributions of CAC members by the researchers and implementers. Our study findings implies that since compensation of CAC members by researchers/implementers may compromise their neutrality and ability to be the "gatekeeper" and perform other roles, more so by being referred to as partner organization staff by the community, it may be high time for researchers, implementers and other actors to advocate for recognition of CACs as a veritable community structure strategic to local governance, especially in service provision and so determine adequate compensation from the local government.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation. The request can be done through https://aphrc.org/microdata-portal/.

Author contributions

Conceptualization: CK, AN, IC, and BM. Data curation, formal analysis, and first draft writing: IC. Methodology: IC, CK, and BM. First draft review: BM, CK, CO, and CA. Final draft review: IC, BM, CK, and CO. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Complementarity of formal and informal actors and their networks in support of vulnerable populations in informal settlements: Governance diaries approach

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Introduction: Beyond several interests and speculations on the relationship between formal and informal actors and their networks in support of vulnerable populations, most studies do not conclusively establish whether the two types of support are substitutes or complements. While informal care and formal care may be substitutes in general, they are complements among the vulnerable groups. Despite how some studies have described complementarity, further insights on the synergy between formal and informal actors and networks are needed to pinpoint how to maximize policy and interventions to alleviate the challenges facing vulnerable groups in informal settlements.

Methods: We conducted an ethnography using governance diaries with 24 participants in Korogocho and Viwandani informal settlements in Nairobi, Kenya. The governance diaries approach involved conducting bi-weekly governance in-depth interviews (IDIs) with study participants for 4 months, complemented with observations, reflections, participant diaries and informal discussions. We used framework analysis approach.

Findings: Informal actors identified include family, neighbors, friends, community groups and community members, and their direct networks. Formal actors on the other hand included government institutions, individuals and authorities that make policies and rules and their desired and possible networks. Both the formal and informal actors and their networks had complementary roles that were beneficial to the vulnerable populations living and working in informal settlements. The complementarities between formal and informal actors and networks in supporting vulnerable groups were portrayed in roles and responsibilities to the vulnerable groups; rules, regulations and governance in supporting vulnerable groups; knowledge, skills and dynamic workforces among formal and informal actors and their networks; information flow on health and wellbeing to the vulnerable populations; transition of actors in supporting vulnerable groups; availability, access and involvement of formal and informal actors and networks to support vulnerable groups. The complementarities allowed for maximum support of the vulnerable populations than otherwise.

Conclusion: We conclude that informal social support is needed regardless of the availability of formal social support. Moreover, a combination of formal and informal actors and related networks are essential to support vulnerable persons. Formal actors should establish, support, or maintain the informal actors and related networks through goodwill and sundry incentives as a vital dimension of building with local

community structures and enhancing inclusion, participation and ownership of policy and program interventions by marginalized and vulnerable groups.

KEYWORDS

formal and informal arrangements, complementarity, informal settlements, marginalized and vulnerable groups, qualitative research, Kenya

Introduction

Although several authors have explored the relationship between formal and informal actors and their networks in support of vulnerable populations (1), most studies do not definitively establish whether the two types of support are substitutes or complements (2, 3). While informal care and formal care may be substitutes in general, they are complements among vulnerable groups (4). Despite how some studies have described complementarity, further insights on the synergy between formal and informal actors and networks are needed (2, 5, 6). Formal actors are institutions, individuals and authorities that make policies and rules and their actions are embedded in formal institutions (7). Informal actors are individuals or groups who have no constitutional mandate and do not have formal rules but still have an influence on service provision (1). In the near absence of formal actors and networks, informal settlements are characterized as ungovernable spaces lacking formal services (7, 8), but the urban poor in such settlements are resilient and often create their own systems to fill gaps in service delivery (9, 10). The service gaps are mostly filled by informal actors (10, 11), often seen with adversarial lens from the point of view of law and order (1, 12). Yet they constitute part of the social fabric and provide complimentary or lacking services and influence, sometimes better than formal actors and networks within informal settlements (13).

Complementary model of support takes into account support from both formal and informal actors and networks through compensation and/or supplementary functions by the actors (5, 6). According to this model, formal actors and networks are accessed when crucial elements of the informal actors and networks are lacking or when there is great need (i.e., greater illness or disability) and the informal actors are unable to provide the required support (3, 5). Most support for vulnerable groups is provided informally by family and friends at home (14). Yet, increasing changing family structures (i.e., single-parent households, decreasing family size and increasing women participation in labor force) means that a growing number of vulnerable groups require and will use formal support services (15, 16). The two types of support can occur simultaneously or can precede or follow each other (3, 17). Even when the two types of care occur simultaneously, informal care may not be a substitute for formal care but a complement for higher skilled tasks (18). A single actor and network may not be able or willing to provide care, suggesting that informal and formal care are not substitutes but compliments in many cases (19), thus the need for more insights on endogeneity inherent in formal and informal actors and networks so as to uncover the complementarity of formal and informal actors and networks (19, 20).

In spaces where only informal support is provided or where only formal support is provided, the vulnerable populations tend to have deteriorated support on health and wellbeing services (21, 22). Where formal and informal service providers have specialization or overlap, evidence point to the vulnerable being better served (5, 6). When there is an overlap, social support received by vulnerable groups seem to be key (23, 24), irrespective of whether it comes from formal or informal sources (2). However, the synergy of formal and informal actors and their networks in support of vulnerable populations in informal settlements is often missed out in the policy discourse and inputs to interventions. Consequently, further insights on the synergy between formal and informal actors and actions are needed to pinpoint how to maximize policy and practice inputs to alleviate the challenges of vulnerable groups in informal settlements (6). Indeed, the linkages between informal-formal actors and networks in informal settlements should be further uncovered for joint utilization of informal and formal actors and networks (25, 26). In Nairobi's informal settlements, informal actors and their networks have engaged and collaborated with the state complementarily to support the vulnerable populations living and working in informal settlements (25, 27). Strategic complementarity enhances a multiplier effect, benefits, expertise and knowledge in supporting vulnerable populations (27). Yet, it is unclear how formal and informal actors and their networks work together to impact the health and wellbeing of vulnerable populations in the informal settlements (28). In seeking to address these knowledge gaps, this study contributes to understanding the following two questions: first, what are the benefits of formal and informal actors? Second, how do formal and informal actors complement each other for the benefit of vulnerable groups?

Literature review

This section presents literature on informal settlements in Kenya; marginalized and vulnerable populations, formal and informal actors and networks, including complementarity of the actors.

Informal settlements in Kenya

Informal settlements are unplanned sites that are not compliant with authorized regulations (29). The widespread growth of informal settlements in urban centers in Kenya has become a central debate in urbanization during the last two decades (30). Yet, the lag by the Kenyan government to improve informal settlements and

Abbreviations: APHRC, African Population and Health Research Center; CAC, Community Advisory Committee; COREQ, Criteria for Reporting Qualitative research; ESRC, Ethics & Scientific Review Committee; IDIs, In Depth Interviews; NACOSTI, National Commission for Science, Technology and Innovation; NUHDSS, Nairobi Urban Health and Demographic Surveillance System; PWD, Persons with Disability.

at least to provide the minimum support on basic requirements and services has led to unimaginable suffering among residents (31). This is coupled by the fact that the government has had the history of failing to recognize the growth and proliferation of informal settlements and thus excludes the urban poor from the rest of the city's development plan (31, 32). While constitutional and attitudinal changes are observable, it is hoped that advocating for the urban poor, particularly marginalized and vulnerable groups would help change the course of events in informal settlements in Nairobi, Kenya.

Vulnerable and marginalized population

Vulnerability refers to the conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of an individual or community to the impact of hazards (33, 34). A vulnerable group is therefore a population that has some specific characteristics that make it at higher risk of falling into poverty (33), those who by virtue of gender, ethnicity, age, physical or mental disability, economic disadvantage, or social status may be more adversely affected in the community than others and may be limited in their ability to claim or take advantage of assistance and related development benefits (33, 35). Marginalization generally describes the overt actions or tendencies of human societies whereby those perceived as being without desirability or function are removed or excluded (i.e., are "marginalized") from the prevalent systems of protection and integration, so limiting their opportunities and means for survival (33). A vulnerable and marginalized individual/group is defined as a group that in a particular context because of its relatively small population or for any other reason, has been unable to fully access basic amenities and participate in the integrated social and economic life as a whole (33, 36).

Children including child-heads of households (CHHs) are more vulnerable to health and wellbeing challenges (36, 37). Three elements of challenges for a CHHs are biological and physical challenges; strategic challenges (i.e., children's limited levels of autonomy and dependence on adults); and institutional invisibility due to a lack of voice in policy agendas (38). Older people face challenges including a lack of access to regular income, work and health care; declining physical and mental capacities; and dependency within the household (35). Without income or work, older people tend to depend on others for their survival and are usually vulnerable in informal settlements where their caregivers also have health and wellbeing challenges (11, 39). Persons with disability (PWD) are often (sometimes incorrectly) assumed to be unable to work and hence increasing their vulnerabilities to health and wellbeing challenges (40). Evidence shows that PWD have higher rates of poverty, and face physical, communication and attitudinal barriers, and a lack of sensitivity or awareness about their circumstances and situations (41). With the clear understanding of different vulnerable and marginalized population, It is widely acknowledged that the populations have unique basic needs from the general population and are harder hit, both in the short and long term, when there is no action taken and thus there is a need for formal and informal actors to take action for their livability (10, 38).

Formal and informal actors and networks

Formal actors are groups or individuals with defined and structured guidelines, whereas informal actors have undefined guidelines (42, 43). Informal actors play a key role to persist and retain legitimacy in informal settlements (2). Informal actors are diverse and may include community members or customary local governance institutions. Often, they fulfill some of the functions expected of the state, yet they are understudied, particularly with regard to how they complement formal actors (6). Within the context of social relationships, complementarity mostly refers to the premise that people tend to seek out other individuals with characteristics that are different yet complementary from their own (a concept sometimes called negative assortative mating by organizational theorist) (6). Philosophers have argued that formal and informal support systems cannot exist in strong form in the same society (17, 44). In this article, the authors argue and demonstrate that such perspectives fail to consider the complementarity of the two systems and the necessity of both for the completion of most tasks, including service provision for the marginalized and vulnerable populations.

Methods

The study is reported per a set of standardized criteria for reporting qualitative research (COREQ) (45).

Study design

This was a qualitative study using the governance diaries method. Governance diaries is an ethnographic approach using more than one method of data collection and where participants make regular records of their daily activities and experiences in relation to actors and who has power in their lives in the provision of social and economic services (46, 47). For this study, governance diaries included in-depth interviews (IDIs), which were informed by participant diaries, informal discussions, participant observations and reflections. Governance diaries are typically used in contexts where there is a need to explore the depth of everyday life, as time allows researchers to spend longer periods in the field for exploration (46, 48).

Study setting

The study was conducted in Korogocho and Viwandani informal settlements in Nairobi, in the areas covered by Nairobi Urban Health and Demographic Surveillance System (NUHDSS) initiated in 2002 by the African Population and Health Research Center (APHRC) (49). Korogocho has a stable and settled population and residents have lived in the area for many years (50), while Viwandani is located next to an industrial area with many highly mobile residents who work or seek jobs in the industrial area (50). A social mapping activity in both settlements identified the most vulnerable groups as persons with disability, older persons and child heads of households. Each of the informal settlements has eight villages, which acted as a guide during the selection of study participants (Figure 1).

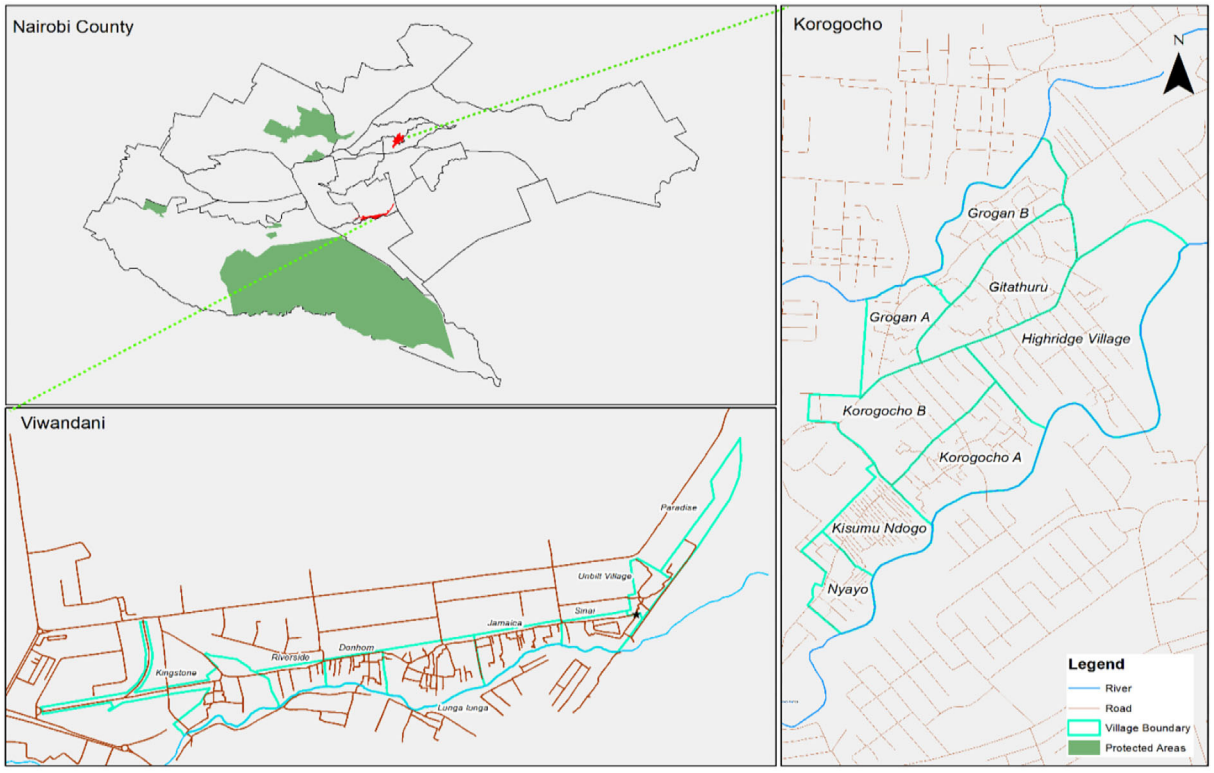

FIGURE 1
Study sites.

Target population

The population of interest were people with disability, child headed households and older persons.

Sampling and sample size

We sampled 24 participants comprising four PWD, four CHHs, and four older persons in each of the study sites. We purposively selected the participants who were residents and benefited from health and wellbeing services from at least two villages.

Data collection process

Community Advisory Committees (CACs) (individuals selected by the community to represent and act as a liaison between the researchers and the community), co-researchers (community members recruited as research assistants because they have a better understanding of the context and with closer rapport with respondents), and the researchers worked together in the recruitment of study participants. We used governance diaries to collect data from January to April 2021 on questions related to the complementarity of formal and informal support actors and related networks for vulnerable populations. Diaries approach entailed IDIs, participant observation, participant diaries, reflection and informal discussions. IDIs were the dominant method and was informed by the other methods. Below is the description of data collection process:

Informal discussions: An informal conversation was carried out between the participants and the researchers to find out key insights and to create rapport with the study participants before the IDIs. The discussions were incorporated in the IDIs.

Reflexive discussions: Reflective discussions were held between pairs of co-researchers on a daily basis, among the whole group of co-researchers on a weekly basis, and between researchers and co-researchers every 2 weeks, to understand the outcome and determine emerging themes and gaps to be probed during subsequent IDIs and routine observations.

Observations: These included observation by the co-researchers, which allowed for a holistic awareness of events as they unfold and as such, enabling more comprehensive understanding of what matters to respondents. We also observed the environment related to our study subjects including observing health and wellbeing services. These observations resulted in photos and insights on what to probe further in the IDIs. The observations were conducted before, during, and after the IDIs to complement the discussions recorded. Reflexive discussions informed the content and concepts for observations.

Participant diaries: We provided the study participants with guidelines pasted on the front of a diary. Each participant would write about daily activities related to formal and informal support actors and related networks at their homes, without writing their names. Co-researchers would call participants and conduct impromptu visits to remind participants about diary writing activities.

IDIs: We used guides with questions on formal and informal support actors, benefits and complementarity of services and service

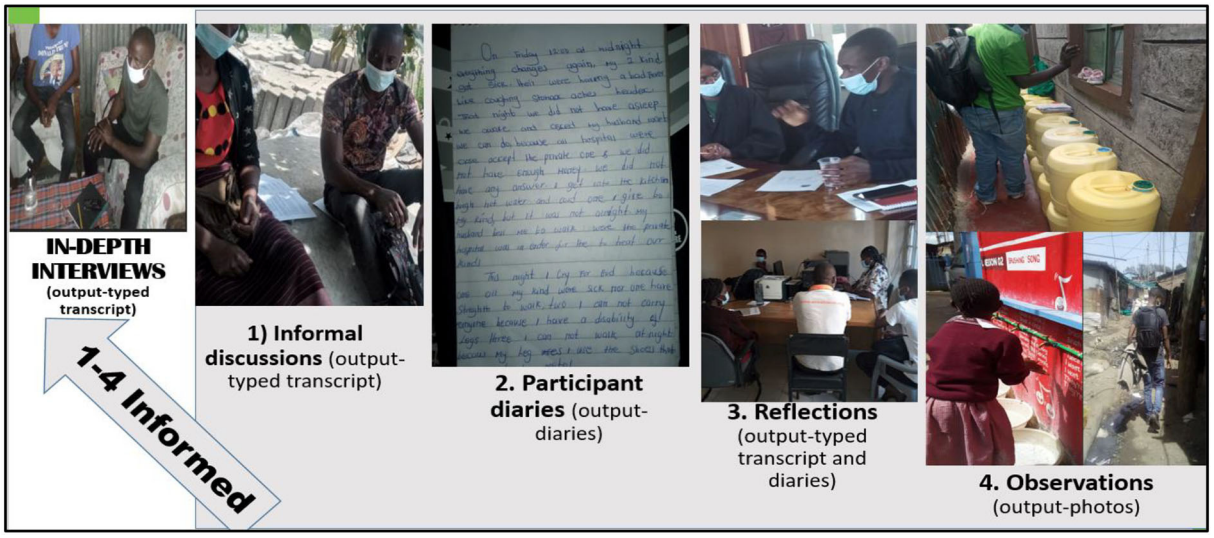

FIGURE 2
Data collection process.

delivery, concerning the vulnerable populations. IDIs for subsequent visits on the same questions were adapted based on observations, reflections, informal discussion and participant diaries (Figure 2). In-depth discussions between the co-researchers and the study participants were administered in pairs of two co-researchers; one who was moderating the interviews and the second, acting as an observer, note taker and facilitator of the recording of the conversations. We reached saturation in the IDIs during the sixth visit when we approached the fourth month.

The outputs from informal discussions, observations, participant diaries and reflexive discussions informed and enhanced robust probing during IDIs. For example, if the co-researchers observed some ambulance or water pipe burst, during IDIs, they would probe more on the pipe bursts and the ambulance. The multi-pronged ethnographic data collection processes are summarized in Figure 2.

Co-researchers received training for 6 days on the aims of the study, data collection process, data collection tools, and research ethics. We piloted the study tools with one older person, PWD and child head of a household in each of the study sites, followed by a debriefing to assess if the study approach and study tools were well understood by both co-researchers and study participants. The pilot exercise enabled us to adjust the translated guides to concepts understood by the study participants and to estimate the time an interview could take. We excluded participants in the pilot from the main study.

Data management

Recorded audios from IDIs, reflections and informal discussions were translated and transcribed from Swahili to English and saved as individual Microsoft Word documents. Outputs (Figure 2) were assigned number codes to prepare for analysis and to ensure confidentiality. Outputs that could not be typed (photos from observations and participant diaries) were scanned and saved in a safe folder, as they were used as reference materials during data analysis.

Data analysis

Transcripts were imported into NVivo 12 software (QSR International, Australia) for coding and analysis. NVivo is a qualitative data management software that can be shared and worked on in groups and facilitate thinking, linking, writing, modeling and graphing in ways that go beyond a simple dependence on coding (51). We used a framework analysis (52). Framework analysis is adopted for research that has specific questions, a pre-designed sample and priory issues (52). The first step of framework analysis was listening to the recordings to familiarize the researchers with the information related to complementarity of formal and informal actors and networks. To ensure reliability, two researchers (an experienced qualitative researcher and an anthropologist) and five co-researchers, who collected the data participated in the development of a coding framework by reading the outputs imported in NVivo 12 software, participant diaries and photos independently to establish an inter-coder agreement. Once the initial coding framework was completed, the team met to discuss the themes generated and to reach an agreement on themes (Table 1). The two researchers proceeded with coding, charting, mapping and interpretation of transcripts.

Ethical considerations

The study was approved by the AMREF Health Africa's Ethics and Scientific Review Committee (ESRC), REF: AMREF-ESRC P747/2020. We also obtained approvals from National Commission for Science, Technology and Innovation (NACOSTI), REF: NACOSTI/P/20/7726. Approval was also obtained from the Liverpool School of Tropical Medicine (LSTM) and the African Population and Health Research Center (APHRC) internal ethical review committees. All participants provided informed written consent before participating in an interview including consent for using photos and videos if there were any.

TABLE 1 Themes for analysis.

Major themes	Emerging themes
Formal and informal actors and networks	Formal actors, their networks and benefits Informal actors their networks and benefits
Complementarity of formal and informal actors and their networks in service delivery to vulnerable groups	Complementarity on roles and responsibilities Complementarity on rules, regulations and governance Complementarity on knowledge, skills and family dynamics Complementarity on information flow to the vulnerable Complementarity on transition of actors Complementarity on availability and access of actors Complementarity on involvement

Results

In addressing our two questions, we present two distinct results out of our study. First in addressing the question, what are the benefits of formal and informal actors, we present formal and informal actors with their diverse networks. In addressing the question of how do formal and informal actors complement each other for the benefit of vulnerable groups, we present findings on the complementarity of formal and informal actors.

Theme 1: Formal and informal support actors and their networks

There was a great deal of shared knowledge about the nature and scope of informal support actors. Participants described how the actors were essential for meeting the health and wellbeing needs of vulnerable populations. Participants described that to support the vulnerable populations, there needed to be functioning support networks, which comprised of direct, possible and desired networks. Informal support actors included family, neighbors, friends and community members and they had much direct role and direct networks. Formal actors included government ministries, community groups, institutions, non-governmental organization and implementers, and they had more of desired and possible networks (Figure 3).

Informal actors who were providing support services for the vulnerable populations directly without using agencies were described to have a direct network, while the formal actors that had the potential of providing support services because they were offering the services in the community were described to have possible networks. There were formal actors who were known by study participants to be of great influence in providing support services but were not felt by the vulnerable groups and were described to have desired networks. Some actors had multiple networks. The network of actors identified by the study participants is summarized in Figure 3.

> *"One can possibly have government services but your life cannot be complete unless you have family doing those normal things directly for you like washing clothes, doing the groceries and all those things in the house and everything like that"* (Older person, Male).

We explored further on the formal and informal actors. As such we asked the study participants questions on (a) what are benefits of informal support actors and networks? (b) What are the benefits of formal support actors and networks? This laid the basis for understanding complementarity of formal and informal actors and their networks.

Informal support actors and networks have multiple benefits

Study participants described how informal actors and related networks reduced exhaustion and stress, as they support the vulnerable populations in performing some chores that would be strenuous. In addition, participants believed that informal support actors and networks helped change attitudes on vulnerabilities and built personal skills for having to deal with anxiety and depression through experiential learning.

> *"When you have a neighbor supporting you, it reduces stress. If there are family members doing some household chores for you, then that gives you relief and reduces being tired"* (PWD, Male).
>
> *"It is the normalizing of old age by neighbors and friends that reduces worries…You meet with other older persons who give you tips on how to adjust to life challenges, as they have also experienced at one point…At this age, we cannot survive without friends"* (Older person, Female).

Furthermore, study participants unanimously described how informal networks were defined as well organized and essential. The participants underscored how informal actors and related networks were accessible, available and dedicated to supporting the vulnerable people in the community.

> *"The informal actors are very organized, dedicated and they are always available to support. I can say they work for 24 hours"* (Child head of a household, Male). *"I don't know them by names and they have the heart to help. I met that youth when I was depressed, she was going to board a bus but she stopped to help me"* (PWD, Female).

The benefits of informal actors and their networks were seen to be collective and additive, that is, the community grew and developed in its capacity to support vulnerable people. Study participants described how informal actors and networks were helpful in resolving issues that would have been resolved by the formal actors.

> *"As years go by and you are not able to do some things, you get to learn about how to seek help from people around…I would say we are going through difficult circumstances but there are volunteer*

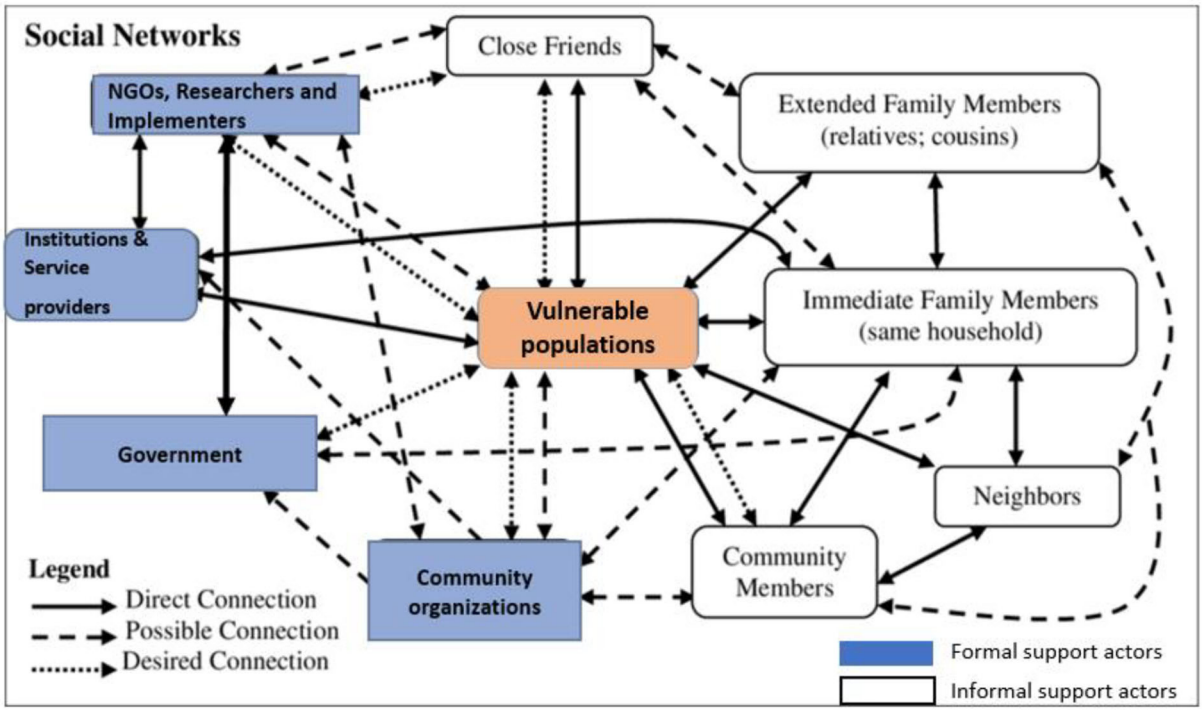

FIGURE 3
Results of network of actors for vulnerable population.

> *individuals who support us all through. If it were not for neighbors, family and youth groups around to do work that should have been done by government, maybe our situation would be worse*" (Older person, Female).

Formal support actors and networks have multiple benefits

Participants did not comment much on the formal actors, as they were not accessible to many vulnerable groups in the informal settlements. However, some of the participants described how formal actors were trained and had expertise on tasks, including but not limited to coordinating support and service provision.

> "*The formal actors are trained and know how to do their work more while supporting us*" (Child head of a household, Male).

Few participants who acknowledged the formal actors and networks, described how the actors and networks played a key role in providing informal actors and networks with information and assurance of support. The study participants consistently stated how the actors and networks performed their roles by sharing skills, knowledge, and stories of caring as well as educating informal actors on needs and expectations of vulnerable persons.

> "*Formal actors support us directly but in many cases they offer support to our caregivers including training. Sometimes they offer skills and take them through the steps of managing emotions and supporting vulnerable groups like us*" (Older person, Male).

Theme 2: A complementary relationship between formal and informal actors and their networks

Beyond the multiple benefits of formal and informal actors individually, we find complimentary benefits of their activities. We asked participants to describe how formal and informal actors and networks complement each other. We present the findings below with different complementarities portrayed on roles and responsibilities; rules, regulations and governance; knowledge, skills and family dynamics; information flow to the vulnerable populations; transition of actors; availability and access of actors and involvement.

Complementarity on roles and responsibilities

Formal actors and networks appear to currently play a minimal role in mobilizing and supporting vulnerable populations. As such religious institutions, neighbors and some social-specific informal groups and networks played a key role in supporting the vulnerable groups efficiently. Despite the minimal role, formal actors and networks were viewed to be important and powerful for the operations of informal actors.

> "*Formal actors and networks play a small role. Quite often it's just friends or church or neighbors who support us on time. The role that formal actors play could be viewed as minimal but they are powerful in the work they do. For example, a policeman here may not be seen frequently, but make the work of informal actors conducive*" (Child-head of a household, Female).

Complementarity on rules, regulations, and governance

There were complex rules and regulations that informal actors were operating within. These included privacy and confidentiality. For example, study participants described how informal actors could be aware that vulnerable people needed help, yet due to privacy, they were unable to mobilize the needed support. However, in such cases, formal actors were described to prioritize assistance at the expense of privacy in their attempt to support vulnerable populations.

> *"Sometimes a friend, family or neighbor could see an old person in need of help but cannot call out for a better support because they do not like disclosing people's secret. However, the formal actors would forgo privacy and ensure someone get help"* (Older person, Male).

Corruption and misuse of public resources by formal actors was unanimously reported. For example, participants described how relief food and other support for the vulnerable groups, distributed by formal actors mostly benefited non-vulnerable groups. However, where formal actors collaborated with informal actors like the women groups, youth groups or religious leaders, the most vulnerable populations always benefited.

> *"They will register You {as individuals to receive aid) but your name will not reflect in the beneficial lists; they will cancel. When the women, youth and religious groups are involved such things related to injustice does not happen...* Some *formal leaders want to take all the aid that comes for themselves, and share with their family members because most of their relatives get relief food and us we do not get* (Child-head of a household, Male).

Complementarity on knowledge, skills, and family dynamics

Some study participants described how informal support actors and networks were highly problematic due to their lack of skills and family dynamics, as many of the actors were not properly trained in handling vulnerable people. The formal actors on the other hand were skilled and trained on handling vulnerable populations and were described to come in handy when called upon by informal actors. Further, informal structures were described as knowledgeable on community and community activities, whereas the formal structures had expert knowledge. As such, more benefits were realized when both actors and networks worked together in complementarity.

> *"There is no training that informal actors go through; they lack knowledge and skills but they offer us counseling here and are handling issues based on convenience and sometimes it can be life-threatening. Formal actors are usually trained and skilled and they are very useful when called upon by informal actors to offer additional support"* (Child-head of a household, Female).
>
> *"Formal actors just do their work. I think they are trained and skilled. However, without informal structures, the formal actors will not understand the community activities"* (PWD, Male).

Complementarity on information flow to the vulnerable populations

Participants reported problems of lack of overall coordination and flow of information about what was available for vulnerable persons. As such, informal actors and networks did not always refer vulnerable persons for specialized services in cases where more specialization was needed. Vulnerable groups also lacked information on where to find support from the formal actors and networks and eventually ends up utilizing the informal actors and networks who are known at the community. By itself, some older child heads of households, older persons or PWD would continue suffering for a long period, while negotiating with informal actors and networks to offer space for formal actors and networks, who had clear communication channels and referrals and were dependable.

> *"Our family members and neighbors who are helping us also struggle, they have so many questions without answers... what do I do? where do I send this person?, how do I refer?' Where's the nearest social worker? So they end up trying all they could to support us.* (PWD, Female).
>
> *"Formal actors have a communication channel and clear ways of referring someone. They are better than the informal actors and are reliable... Many people here do not know where to go when they need support, as such they resort to neighbor, family and anyone around"* (Child-head of a household, Male).

Complementarity on transition of actors

The changing nature of communities and informal actors and networks was a barrier to supporting the vulnerable population. The changes in the community included family income, economic recession, retirement, thus losing social networks and migration. In addition, a belief that if people have strong networks throughout their life will also have strong networks of support in old age and vice versa, brought forth challenges to individuals who were isolated at the time of our study. The formal actors on the other hand were described to have a clear succession plan for takeover on supporting vulnerable populations.

> *"There has been a lot of relocation, as such the individuals who already knew our challenges have left. This has affected us... If somebody has lived their life isolated... when it comes to old age that's how they will be isolated"* (PWD, Female).
>
> *"Those support actors who are working under government are better placed because they have a good handover when they retire from work"* (Older person, Male).

Complementarity on availability and access of actors

Informal actors and networks were perceived to be easily accessible from the community and were described to be efficient. Whereas, formal actors and networks were not accessible hence not preferred by the vulnerable groups in the informal settlements. As such, informal actors and networks filled gaps in service provision enabling service provision to people who did not have an extensive formal support.

> *"Some formal structures come here and initiate some project activities to support us and disappear completely. To be sincere the support activities are not running well. If it were the neighbors or the family members initiating them, they would be here every day following up on how the activities operate"* (Older person, Female).
>
> *"The informal support help us understand a belief that informal actors and networks will always exist to provide support where formal actors and networks do not exist* (PWD, Male).

Study participants described how hierarchies in accessing formal actors for support was highly reported. This is because formally and administratively, some community steps should not be bypassed. The chain in the hierarchies was described to affect efficient access to support services. On the other hand, in cases where efficient services were needed, informal actors and their networks were preferred.

> *"We mostly go to the chairman first because you cannot bypass steps. You start from the ground going up to other higher hierarchies in the government. By the time you get the solution, maybe you have suffered much. If you go to neighbors, family member or the religious leaders, you do not have to think of hierarchies while in need of a solution"* (PWD, Male).
>
> *"Sometimes the chain of command is complicated since if you want to go to the chief they will send you to the chairlady, chairman's and so on and you cannot easily access them, and this is the reason why vulnerable people rarely get support"* (Child-head of a household, Female).

Complementarity on involvement

Low involvement in the community was also reported to affect the success of formal actors' roles in the community. Support from informal actors on information of who needs support, where and when resulted in formal actors being effective in support for the vulnerable populations.

> *"There is this NGO; they came here and stationed sanitation facilities without consulting. We ended up not using them. When youth groups are involved, they usually consult with us and our issues are featured"* (PWD, Male).

This led us to ask for an example of a "best practice" in social networks for formal actors and networks to involve and work with already-established community organizations, or the individuals who are already supporting the vulnerable populations. This is because there were few cases where participants described formal actors working directly with vulnerable populations.

> *"All social networks available should be strengthened from all angles by everyone and formal actors and networks should aim at working with groups and individuals who have already started working with us"* (PWD, Male).

In conclusion, empowering the vulnerable groups with information on the support to obtain from formal actors will greatly enhance complementarity of support. Among informal actors, the interactions varied depending on the intimacy and behaviors of the recipients of support. Moreover, it is important to encourage informal actors to make their services complimentary by recording individual and family requirements (i.e. financial or humanitarian or medical support), which could lead to a collaborative process between formal and informal actors.

Discussion

We explored the complementarity of formal and informal actors and related networks in support of vulnerable groups in informal settlements using governance diaries approach, supported by a multi-pronged ethnographic data collection processes which included participant diaries, IDIs, informal discussions, observations and reflective sessions. The key findings highlight the need to critically question the assumptions and rationale that lie behind the existence of dichotomous formal and informal support actors in silos as it relates to vulnerable populations in informal settlements. This is because complementarity of actors in delivery of services best captures the current relationship between the formal and informal support actors (3). Study participants described how informal actors and networks provided support to vulnerable persons because the formal actors and networks were non-existent or near-absent in service delivery in informal settlements. Our results showed that informal actors and networks are essential as they provide both task-oriented and emotional support to vulnerable persons. The informal actors and networks were considered to be naturally forming, organized, and unique in supporting the needs of the vulnerable populations in many cases (6). Our findings described how formal actors provided professional and specialized support as they were trained and skilled and at times supported the informal actors to offer better support.

Our results also showed how informal actors, though filling important service delivery gaps, were identified as highly problematic as they were not qualified and had difficulties working. These challenges underscore their inability to replace formal actors and call for at least the complementing roles of formal actors and related networks. This dimension is related to other studies describing the need to exercise caution to avoid assumptions that formal support does not matter since providing formal social support is essential in support of the vulnerable population (2, 6). While this is what formal actors are statutorily tasked to do, this is an important finding in our study context, as formal actors are usually seen as oblivious or insensitive to the needs of the vulnerable populations in informal settlements (7, 53). Notwithstanding, evidence on complementarity suggests that the public approach to the social support of the vulnerable population through informal structures is uncommon or yet to be embraced and utilized by the majority of formal structures (5, 6). The implication is that while there may be tensions between formal and informal actors and networks, our results suggest that participants would welcome guidance and resources to enable them to operationalize social support for vulnerable populations through complementarity of functions of formal and informal actors and networks. This is supported by other studies, describing that social support is perceived to be helpful and individuals need guidance on operationalization (2, 5).

Participants were already positively disposed to the benefits of both formal and informal actors and networks and this included reaping both community knowledge and expert knowledge. This is a profound finding and presents itself as an opportunity for utilizing dual knowledge in supporting the vulnerable persons in the community. It counters the narrative which places services from formal actors as outside of the community, as somehow

different and less trusted (54, 55). In reality, some formal actors and networks are sometimes members of the community (2, 5, 6), lived, worked and available to play roles as informal actors and networks in support of vulnerable populations. Another implication is the clear scope we found for formal actors and networks to target and support informal actors and networks through already existing community groups such as schools, religious institutions, and social clubs thus developing partnerships, community capacity and consequent increased benefits to the vulnerable groups (37). This is because the formal actors and networks are usually called upon when the informal support have exhausted their capability and the situation of the vulnerable has deteriorated so much that the informal network requires assistance to cope or critical elements of the informal network are missing. Our findings are speaking to a wider emerging evidence of significant improvements in health outcomes among slum dwellers in Nairobi within relatively short periods, following interventions that promoted collaboration and cooperation of multiple actors, including formal and informal service delivery structures. While not primarily focusing on complementarity, an intervention research program on maternal and child health—the Partnership for Maternal, Newborn and Child Health (PAMANECH) in Korogocho and Viwandani slums—implemented between 2012 and 2016 increased the capacity of private health facilities in the slums to provide basic emergency obstetric care and significantly reduced home deliveries, by bringing together local health service providers and officials of Ministry of Health in a complimentary than adversarial relationship (56). Further, as part of the search for pathways to address the challenge of health inequity between slum and non-slum urban dwellers, another study highlights the complementary roles of mobile outreach services and implementation research studies in expanding healthcare access to hard-to-reach but vulnerable groups in informal settlements beyond public facilities and other traditional service delivery models (57, 58). It suggests like our current study, the potential promise of nontraditional service delivery models that are convenient and adaptable to specific contexts in bridging service access and utilization deficits among disadvantaged populations.

Conclusion

In line with the present findings, we conclude that informal actors and networks for social support of vulnerable populations are needed regardless of the availability of formal actors and networks more so in the informal settlements. This is because there is a prevailing near absence of many critical formal support in informal settlements and so informal actors and networks have devised support network mechanisms. Our findings underscore the need for a consequential engagement with informal stakeholders and incorporation of their rich local intelligence, often ignored and generally not quantified, documented, harnessed, nor incorporated into policy and action. Nevertheless, mechanisms that entails a complementarity of formal and informal actors and related networks are essential to support vulnerable persons because informal structures are knowledgeable on community and community activities, whereas the formal structures have expert knowledge. Formal actors and related networks should establish, support, or maintain the informal actors and related networks through goodwill and broader scope. Shifting the focus of complementarity of formal and informal actors and networks from a point of control to autonomy and collaboration would be a significant step in empowering vulnerable groups to make decisions about where to seek support. Comprehensive education and skills development that enables vulnerable groups and their caregivers to determine where, how, when and why to seek support from both formal and informal support actors and networks, and that seeks to ensure informed decision-making—is the best antidote to advancing support to the vulnerable populations in informal settlements. Lack of support can only persist in the context of misinformation and darkness, which is why efforts to raise awareness are essential and need to go further.

On the global agenda, our findings of complementarity speaks to calls for not only breaking down traditional silos but building more cross-sectoral decision-making and multi-stakeholder partnership approaches and links among sectors, an era ushered by the SDGs 2030. It is typified by joint actions by health and other government sectors, representatives from private, voluntary and non-profit groups, to improve the health of populations, with actions taking the forms of cooperative initiatives, alliances, coalitions or partnerships and co-creation of solutions. These lend impetus for the need to extend the tradition in seeking complementarity between formal and informal structures in addressing the challenges of vulnerability and marginality among the urban poor; a call consistent with incorporating rich local intelligence, adaptive capacity and survival instincts as integral part of the building blocks for policy and action in the region and beyond.

Data availability statement

The data presented in this study is available on request from the corresponding author. Other data related to this study is not publicly available because it is included within upcoming articles and cannot be shared at this time.

Ethics statement

This study was conducted in accordance with the Declaration of Helsinki, and approved by the AMREF Health Africa's Ethics Scientific Review Committee (ESRC), REF: AMREF-ESRC P747/2020. A research permit from National Commission for Science, Technology and Innovation (NACOSTI), REF: NACOSTI/P/20/7726 was also obtained. Approval was also obtained from the Liverpool School of Tropical Medicine (LSTM) and the African Population and Health Research Centre (APHRC) internal ethical review committee. All participants provided informed written consent before participating in an interview including consent for using photos and videos if there were any. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Author contributions

Conceptualization: IC, CK, and BM. Data curation, formal analysis, and writing–original draft: IC. Methodology and writing–

review and editing: IC, CK, AS, EI, and BM. All authors approved the manuscript for submission.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Green space justice amid COVID-19: Unequal access to public green space across American neighborhoods

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Countries around the world have resorted to issuing stay-at-home orders to slow viral transmission since the COVID-19 pandemic. During the lockdown, access to public park plays a central role in the public health of surrounding communities. However, we know little about how such an unprecedented policy may exacerbate the preexisting unequal access to green space (i.e., green space justice). To address this research void, we used difference-in-difference models to examine socioeconomic disparities, urban-rural disparities, and mobility disparities in terms of public park access in the United States. Our national analysis using the weekly mobile phone movement data robustly suggests the following three key findings during COVID-19: (1) The elderly, non-college-educated people, poor people, and blacks are less likely to visit public parks frequently, while unemployed people appear to be the opposite. (2) Compared to rural areas, populations in urban neighborhoods appear to visit public parks more frequently and they generally go to larger parks to minimize the risk of infection. (3) Populations in neighborhoods with higher private vehicle ownership or those with a higher density of transit stops would more frequently visit and travel a longer distance to public parks during the stay-at-home order. Our results imply that conventional inequality in green space access may still exist and even become worse during COVID-19, which could negatively impact people's health during isolation. We suggest that special attention should be paid to park-poor neighborhoods during the pandemic and in the post-pandemic recovery phase.

KEYWORDS

COVID-19, green space justice, stay-at-home order, mobile phone data, neighborhood analysis

1. Introduction

Since the outbreak of COVID-19, public health entities have repeatedly underscored the importance of practicing social distancing and staying at home to minimize interpersonal contact. Many restriction measures such as border closure, indoor gathering limitation, social distancing, and stay-at-home orders have been adopted around the world to slow viral transmission, to relieve the pressure on health care systems, and, simply, to prevent excess deaths (1). These restrictions can adversely affect people's wellbeing due to isolation and inadequate physical activities, thereby further reducing people's ability to combat the virus (2). Local streets, public parks, trails, etc., are the main places where outdoor activities take place (3). Therefore, public park visitations, including forest excursions, increased significantly during the restricted period in response to the policy (4). Public parks can not only serve as a substitute and shelter for the majority of the population during a sustained pandemic, as long as visitors take a more isolated path in parks (5), but also enhance longstanding resilience because of the positive impacts on people's mental and physical health (6, 7).

Improving access to public parks is a critical strategy with a high return on investment, especially for socially disadvantaged groups, who can benefit more from green space (8). However, socially and economically disadvantaged populations, such as low-income people (9), ethnic minorities (10), less-educated people (11), immigrants (12), and the elderly (13) are all well-documented to have less access to green space in terms of the size, amenities, maintenance standards and security levels (14). Additionally, the existing research on green space justice was largely focused on the urban context, while the urban-rural differences with respect to green space access can vary substantially (15). Moreover, insufficient mobility resources may further exacerbate inequality. In the UK, people returning to work are more likely to drive a private car than taking public transport for infection concerns (16). Nevertheless, people without a private vehicle still might not take public transit because many countries have restricted the operation of public transit for work or non-essential trips during the pandemic (3).

The lockdown during the pandemic would restrict people's mobility, especially for the marginalized populations who are primarily dependent on public transit. The pandemic thus might further exacerbate inequalities in green space access for people who cannot visit any park within walking distance. However, the impact of COVID-19 on such inequalities is yet understudied. To address this research gap, we analyzed the visitations to public parks from all neighborhoods in the contiguous United States (US) to answer the following three research questions: (1) whether disadvantaged neighborhoods with varying socioeconomic characteristics have sufficient access to public parks during COVID-19? (2) Whether neighborhoods in rural areas have sufficient access to public parks during COVID-19? (3) Whether mobility-poor neighborhoods have sufficient access to public parks during COVID-19?

Hence, this study first comprehensively explores the nationwide inequality in green space during the pandemic at the neighborhood level. Also, this work employed the multiple-source data to examine different types of inequality in the United States. The rest of this article proceeds as follows. We first review the existing relevant literature to provide a research contextual backdrop. We then present the data for this research and specify the methods used for the analysis. Finally, we present the findings and conclude with policy implications and future research.

2. Literature review

2.1. Social disparity and green space access during COVID-19

As a form of public assets, public parks are expected to be distributed equally across the neighborhoods (17, 18). However, the existing studies in environmental justice suggest that green space is not equally accessed due to socioeconomic disparities of neighborhoods (10, 19, 20).

Specifically, age is a determining factor that is pertaining to people's access to public parks during the pandemic. The elderly people have less access to public parks because of the inconvenience of mobility and need to be taken care of Iraegui et al. (13). Gated public parks for preventing antisocial activity unintentionally meant that the disabled elderly people could not access such spaces by themselves. Knowles and Hanson (21) found that the stay-at-home order confined older people to stay in indoor spaces, with fewer chances to go outside and visit public parks. In addition, Chiou and Tucker (22) found a similar finding that during COVID-19, neighborhoods with more older people have a high proportion of stay-at-home residents. Likewise, Dasgupta et al. (23) found that communities, with high compliance of social distancing during the pandemic, had 8.2% fewer youth and 7.4% more elderly.

Low-income neighborhoods lack access to high-quality public parks, especially for newly constructed low-socioeconomic communities (9). During a pandemic, poor people are more likely to visit small and congested green spaces, which are not suitable for physical exercise and risky for viral transmission (18). Zhai et al. (4) also observed that residents in low-income counties have fewer visitations to public parks than those in high-income counties in the US during the early outbreak of COVID-19.

Most of the ethnic minorities have lower socioeconomic status with less wage (24, 25), less car ownership (17, 26), and longer working time (27), which make them difficult to access public parks in longer distances. Also, ethnic minorities are more likely to face discrimination by visitors, police, and staff in green spaces (10, 28). By conducting a survey in New York City, Lopez et al. (29) found that public park use was lower for Hispanic communities, and the importance of public park for health was perceived as lower for black respondents during COVID-19. However, whether ethnic minorities across the US face insufficient access to public park have not be empirically evidenced.

Employment status is also determining people's access to public parks, especially considering that recent empirical studies have explored the heterogeneous impacts of governmental interventions on different occupations (30, 31), making a growing number of unemployed during the pandemic. Coombes et al. (32) adopted the employment rate as one the demographic measures for public park access. When examining the association between greenspace, urbanity, and human health in England, Mitchell and Popham (33) typically considered employment deprivation for statistical model controlling.

Inequalities with respect to education have been proved to be associated with green space access by the existing literature (34–36). Many case studies in Europe and North America have shown that access to either private green space or public green space is largely determined by education level (37–39). Moreover, Cole et al. (11) observed that the quality of green space is lower in less educated neighborhoods. Notably, well-educated people are more likely to trust science and comply with stay-at-home order (22), thereby actively reducing visitations to green spaces during the pandemic.

To sum up, the existing studies suggest that neighborhoods with varying median age (13), income (4), ethnic minorities (10), unemployment rate (33), and education level (11) may have heterogeneous access to public park. However, the research on the association between COVID-19 and public park access, as of spring 2021, is still limited because previous findings may not include the pandemic context. Specifically, previous studies mainly rely on cross-sectional survey data on routine days to examine the association between social disparity and public park access. However, few of the existing studies are in the context of COVID-19, regarding that due to the dynamic change of COVID-19 and unprecedent stay-at-home order, people's behaviors can be totally different from previous patterns (40). That is, the existing knowledge may not hold ground in

many ways during such a pandemic, necessitating a comprehensive exploit on the public park access with the dynamic data.

2.2. Urban–rural disparity and green space access during COVID-19

Despite the primary focus on public park access in urban areas, rural areas should not be overlooked. The existing literature supports that people living in rural areas tend to have insufficient mobility (15) and low-quality park facilities (41), so that people in rural areas visit green space much less frequently (42). Wen et al. (15) found that the median distance to the near public parks for rural neighborhoods was 10 times that for neighborhoods in principle urban centers in the US. Likewise, in Europe, Wolff et al. (43) found that the average proximity to public park for urban residents is 13 times larger than that for rural residents. Maas et al. (8) and Mitchell and Popham (33) both found that the association between green space and health varied is determined by the degree of urbanity in an area. Richardson et al. (44) found that the effects of green space on residents' health outcomes may vary from the rural area to urban core because the role of green space is more impactful in the context of urban environments in contrast to rural environments. However, Zasada et al. (45) argue that increasing population density, the insufficient availability of green space, and the overuse of public parks can collectively lead to the decreasing attractiveness of recreational possibilities for urban residents. Mitchell and Popham (33) also argue that suburban and rural residents generally have their domestic gardens so that they have limited demand for public parks as compared to urban residents, rather than that they cannot access public parks.

Therefore, the impact of urban–rural disparity on public park access is still inconclusive when researchers use data on normal days, which could be more complicated during COVID-19, because Mueller et al. (46) found that the situation of the pandemic in rural areas have been dreadful, with significant negative influences on people's travel behavior, life satisfaction, and overall health. Rice et al. (47) found that, since the outbreak of COVID-19, the outdoor recreation activities and distance traveled have declined significantly more among urban residents than rural residents by conducting an online survey. Although urban-rural disparity has drawn widespread attention during COVID-19, the existing literature has not explored whether there is an association between the urban-rural disparity and public park access. However, addressing such question is essentially important for policymakers to identify and enhance park-poor neighborhoods from a geographic perspective, especially during the pandemic.

2.3. Mobility disparity and green space access during COVID-19

Mobility resource is another contributing factor for green space access. Nissen et al. (48) suggested that untangling the relation between mobility and green space can help enhance the wellbeing of people. Wendel et al. (49) found that public transit is the most frequent transport method for people to access green space, followed by private vehicles. Likewise, Fan et al. (50) demonstrated that the average travel time to public parks can be reduced either by improved public transport systems or higher availability of private vehicles. Haslauer et al. (51) considered the access to public transit as the main factor of green space availability. Europe (52) suggested that the 300-m buffer was chosen for measuring the public park access because 300 m represent a 5-min walking distance to the nearest transit stop, which ensures access to parks for people without a car. However, the closest park is not always the most visited. This is particularly true in Western car-oriented countries because public parks spreading over comparatively large areas is highly associated with mobility supplies (15).

Therefore, public transport and private vehicles have been widely acknowledged to impact public park access. However, during the pandemic, transit stops and vehicles are considered as high-risk environments due to the crowded environment, the plenty of surfaces that help spread the virus, and the insufficient testing of passengers (53). To this end, Zhang et al. (54) documented notable modal shifts away from public transit usage because over 60% of survey respondents agree that the car dependence of passengers may increase because of adverse response to crowded public transit environment during the pandemic. Wilbur et al. (55) found a drop of transit ridership in Tennessee, USA due to COVID-19, which may keep people away from green spaces. In New York City, Teixeira and Lopes (56) also found that some transit users changed mode to the bike sharing service. Since the outbreak of COVID-19, even though we know that the mode shift occurs, how the public transport resource and car dependence have impacted neighborhood-level access to nature parks has not been empirically understood, complicating the decision-making process of bridging the gap of green space inequality from a transport perspective.

3. Data

3.1. Data source

In this study, we chose all the census tracts in the contiguous US to be our study area. After excluding the ones with missing data, a total of 69,867 census tracts were included for the subsequent analysis. Then, we first retrieved weekly mobile phone movement data and visitor insights data for physical places from SafeGraph (57) (https://www.safegraph.com/). Our dataset ranges from January to May in both 2019 and 2020. Based on the Points of Interest (POI) category, we extracted 90,013 urban-park POIs within the contiguous US. A POI is a specific point location that someone may find useful or interesting. Thereafter, we connected all the urban-park POIs with their origin neighborhoods to quantify the measures of access to public parks for each neighborhood, including the average distance people traveled to public parks, the average size of the public parks people visited, and the proportion of people who have visited public parks. These three metrics are derived from the existing literature pertaining to public park access (20, 58). The detailed description of such dataset and the metrics can be found in Supplementary material.

Second, to explore the effects of socioeconomic and demographic characteristics on public park access, we retrieved the 2018 American Community Survey (ACS) database (https://www.census.gov/programs-surveys/acs/data.html) to construct estimates of the poverty rate, the percentage of non-college-educated people, the percentage of elderly people (age 65+), the unemployment rate (i.e., the percentage of people who are not employed before the pandemic,

excluding retirees), the percentage of blacks for each neighborhood. Note that we mainly consider the blacks in this study because the literature indicates that blacks are the most vulnerable to COVID-19 transmission (59–61).

Third, to understand the urban-rural disparities, we employed the urban-rural classification scheme developed by the National Center for Health Statistics (62) for all US counties (https://www.cdc.gov/nchs/data_access/urban_rural.htm). Specifically, six levels (Large Central Metropolitan, Large Fringe Metropolitan, Medium Metropolitan, Small Metropolitan, Micropolitan, Noncore Area) are categorized in the classification scheme, which is determined by the population size of the corresponding county.

Fourth, in terms of the mobility data, we collected the locations of transit stops across all the neighborhoods from the General Transit Feed Specification (63) (https://gtfs.org/). By overlaying the bus stops with census tract by ArcGIS 10.6, we can calculate the density of transit stops for all neighborhoods. In addition, the average number of private vehicles for each household can also be collected from ACS database.

We assume that the public social-distancing behaviors are guided and influenced by the stay-at-home order. To this end, we collected statewide stay-at-home orders from Mervosh et al. (64). Specifically, 43 states had issued stay-at-home orders to encourage residents to shelter in place. However, some counties had also issued a more stringent local order than the state. For instance, the Florida governor did not issue the state-level stay-at-home order until April 1st, while the majority of Florida counties had already put local directives in place by March 25th. Hence, we also collected a county-level stay-at-home order from Keystone Strategy (65). Specifically, 592 out of 3,142 counties had issued a county-level order. We later combined the county-level and state-level orders to determine whether a county was under a stay-at-home order based on the earlier order.

3.2. Descriptive statistics

Table 1 provides summary statistics of the key variables. Note that the socioeconomic variables, urban-rural variables, and mobility resource variables are all cross-sectional data while the remaining variables are panel data. Since visitation to public parks exhibits varying seasonal patterns (66), showing the variations solely in 2020 cannot explicitly reflect people's behavior changes due to COVID-19. Figure 1 illustrates the interannual change of visitation to public parks based on the data of 2019 and 2020. In the US, the first case of COVID-19 was reported in January 2020, but a national emergency was not declared until March 13th, 2020. Therefore, in January, it is not surprising that the number of visitors in 2020 even increased compared to that in 2019. In February 2020, for over 60% of parks, the number of visitors has increased by at least 5% compared to that in February 2019. However, with the pandemic on a rampage in March and April, the total number of visitors had thus fallen by 48%, and the number of visitors in over two-third of public parks significantly declined, particularly in the West Coast, East Coast, and the Southern US. Meanwhile, interestingly, the Midwestern US still had a significant increase. Starting in May, the visitations to most parks have clearly declined across the country.

4. Method

4.1. Examining socioeconomic disparities

The difference-in-differences (DID) method is a quasi-experimental approach that compares the changes in outcomes over time between the treatment group and the comparison group. We first used the DID estimation method to compare neighborhoods with varying socioeconomic characteristics before and after the issuance of stay-at-home order.

$$\begin{aligned} Metrics_{nit} &= \alpha_1 PostOrder_{it} + \alpha_2 PostOrder_{it} \times Elderly \\ &+ \alpha_3 PostOrder_{it} \times NoDegree + \alpha_4 PostOrder_{it} \\ &\times Poverty + \alpha_5 PostOrder_{it} \times Unemployment \\ &+ \alpha_6 PostOrder_{it} \times Black + \gamma_i + \delta_t + u_{it} \end{aligned} \quad (1)$$

For $Metrics_{nit}$, it represents n-th metrics for access to public parks, including distance traveled to public parks, the average area of public parks that people traveled to, and the percentage of people visited public parks in the census tract i on week t. We define that calls for stay-at-home represents the outbreak of each county so that we use the issuance date as the cutoff to determine the "treatment" period. Coefficient α_1 captures the effects of the stay-at-home order on different metrics. Note that, throughout all the models, we define $PostOrder_{it} = 1$ when the stay-at-home has been in place in the census tract i; otherwise, it is zero. Coefficient α_2, α_3, α_4, α_5, and α_6 represents the effects of the proportion of elderly people, the proportion of non-college-educated people, the poverty rate, the unemployment rate, the proportion of blacks on the access metrics, respectively.

In particular, γ_i represents census tract-specific dummy variables that take a value of 1 for census tract i and a value of zero for other census tracts. These fixed effects can guarantee that census tract-specific factors, which are constant over time are controlled for during the investigation. In addition, δ_t represents week-specific dummy variables that take a value of 1 for week t and a value of zero for other days. These fixed effects guarantee that week-specific factors, which are common across neighborhoods, are controlled for during the investigation. Finally, u_{it} represents residuals.

To avoid bias due to the seasonality of visitation to public parks, we conducted the analysis by comparing the changes between 2019 and 2020, as indicated in Equation (A2).

4.2. Examining urban-rural disparities

We then examined the unequal access to public parks in urban and rural areas by using the following DID model:

$$\begin{aligned} Metrics_{nit} &= \beta_1 PostOrder_{it} + \beta_2 PostOrder_{it} \times LargeCentral \\ &+ \beta_3 PostOrder_{it} \times LargeFringe + \beta_4 PostOrder_{it} \\ &\times MediumMetro + \beta_5 PostOrder_{it} \times SmallMetro \\ &+ \beta_6 PostOrder_{it} \times Micropolitan + \gamma_i + \delta_t + u_{it} \end{aligned} \quad (2)$$

Coefficient β_1 captures the effects the stay-at-home order on different metrics of access to public parks. Coefficient β_2, β_3, β_4, β_5, and β_6 captures the additional effects of the large central metro area, large fringe metro area, medium metro area, small

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TABLE 1 Descriptive statistics of all variables for all census tracts.

	Description	Type	*N*	Mean	Std. Dev	Min	Max
Dependent variable							
Year 2020 (January–May)							
Distance (km)	The average distance that people travel to public parks in 2020.	Weekly	1,108,086	19.78	31.48	0.12	427
Size (km^2)	The average area of public parks that people travel to in 2020.	Weekly	1,108,086	0.01	0.04	0.001	1.15
Visiting public parks	The proportion of a neighborhood that people visit public parks in 2020.	Weekly	1,108,086	0.14	0.11	0	1
Year 2019 (January–May)							
Distance (km)	The average distance that people travel to the public parks in 2019.	Weekly	1,108,086	23.50	32.11	0.12	538
Size (km^2)	The average area of public parks that people travel to in 2019.	Weekly	1,108,086	0.01	0.03	0.001	1.15
Visiting Public parks	The proportion of a neighborhood that people visit public parks in 2019.	Weekly	1,108,086	0.06	0.04	0	1
Independent variables							
Socioeconomic and demographic characteristics							
Elderly	The proportion of people who are older than 60 years old	Cross-sectional	69,867	0.16	0.08	0	1
No college degree	The proportion of non-college-educated people	Cross-sectional	69,867	0.79	0.14	0	1
Poverty	The proportion of people in poverty status	Cross-sectional	69,867	0.15	0.11	0	1
Black	The proportion of Black people in the neighborhood.	Cross-sectional	69,867	0.13	0.23	0	1
Unemployment	The proportion of unemployed people	Cross-sectional	69,867	0.06	0.04	0	0.5
Urban-rural variables							
Large central metro	Neighborhoods in metropolitan statistical area (MSA) of 1 million population with three conditions[a].	Cross-sectional	21,920				
Large fringe metro	Neighborhoods in MSAs of 1 million or more population that do not qualify as the large central metro.	Cross-sectional	15,445				
Medium metro	Neighborhoods in MSA of 250,000–999,999 population	Cross-sectional	14,289				
Small metro	Neighborhoods in MSAs of <250,000 population	Cross-sectional	6,307				
Micropolitan	Neighborhoods in micropolitan statistical areas	Cross-sectional	6,349				
Noncore area	Neighborhoods not in a micropolitan statistical area	Cross-sectional	5,113				
Mobility variables							
No vehicle available	The proportion of household that has no vehicle	Cross-sectional	69,867	0.09	0.12	0	1
One vehicle available	The proportion of household that has one vehicle	Cross-sectional	69,867	0.33	0.12	0	1
Two vehicles available	The proportion of household that has two vehicles	Cross-sectional	69,867	0.37	0.11	0	1
Three vehicles available	The proportion of household that has three vehicles	Cross-sectional	69,867	0.14	0.07	0	1
Four or more vehicles available	The proportion of household that has four or more vehicles	Cross-sectional	69,867	0.07	0.05	0	1
Density Of Transit Stops	Number of transit stops per square mile	Cross-sectional	69,867	11.26	24.06	0	484.38
Stay-at-home order							
Under order	The census tract is under the stay-at-home order	Weekly	490,353				
Not under order	The census tract is not under the stay-at-home order	Weekly	618,633				

[a](1) Contain the entire population of the largest principal city of the MSA, or (2) are completely contained in the largest principal city of the MSA, or (3) contain at least 250,000 residents of any principal city of the MSA. A metropolitan statistical area (MSA) is a geographical region with a relatively high population density at its core and close economic ties throughout the area.

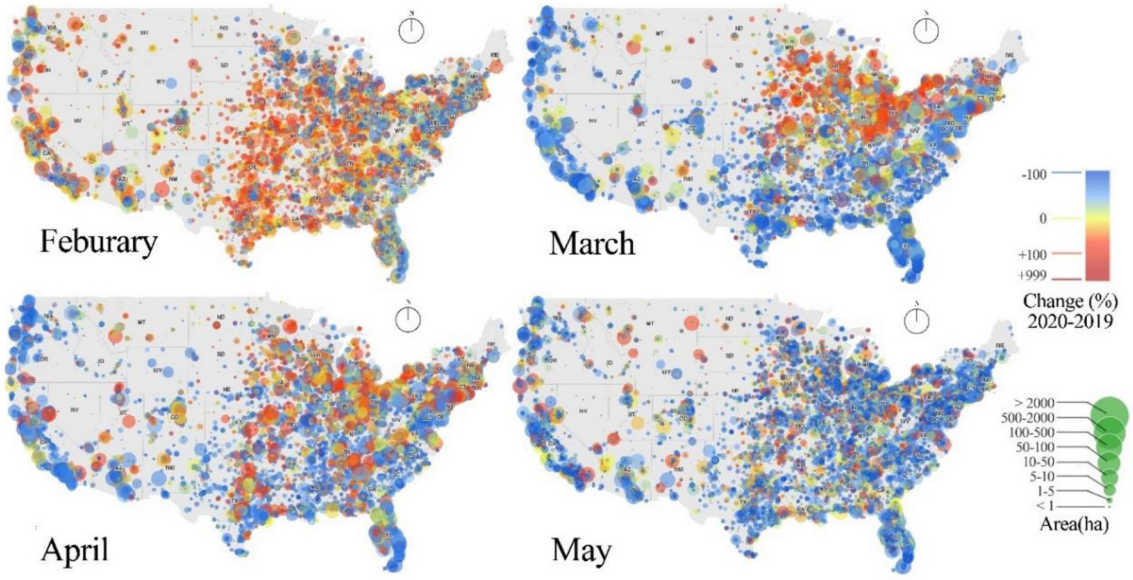

FIGURE 1
The change in the number of public park visitors between 2019 and 2020.

metro area, and micropolitan on the access metrics, respectively. Note that the variable "Noncore Area," which represents the census tracts in rural areas, is the reference variable so that it is not indicated in the model. The interpretations for γ_i and δ_t are same as that in Equation (1). Again, to avoid the bias of seasonal effects, we robustly examine urban-rural disparities using the data of 2019 and that of 2020, as shown in Equation (A3).

4.3. Examining mobility disparities

Lastly, the formal investigation on mobility resources is also accomplished by using a DID model, where weekly changes of access to public parks are regressed on the stay-at-home order and availability of vehicles.

$$\begin{aligned} Metrics_{nit} &= \theta_1 PostOrder_{it} + \theta_2 PostOrder_{it} \times OneVehicle \\ &+ \theta_3 PostOrder_{it} \times TwoVehicle + \theta_4 PostOrder_{it} \\ &\times ThreeVehicle + \theta_5 PostOrder_{it} \times FourMoreVehicle \\ &+ \theta_6 PostOrder_{it} \times Transit + \gamma_i + \delta_t + u_{it} \end{aligned} \quad (3)$$

Coefficient θ_1 captures the effects the stay-at-home order on different metrics of access to public parks. Coefficient θ_2, θ_3, θ_4, θ_5, and θ_6 captures the additional effects of availability of one vehicle, availability of two vehicles, availability of three vehicles, availability of four or more vehicles, and the density of transit stops, respectively. Note that the variable "No Vehicle Available" is the reference variable so that it is not indicated in the model. The interpretations for γ_i and δ_t are same as that in Equation (1). Once again, we also robustly examine urban-rural disparities using the data of 2019 and that of 2020, as indicated in Equation (A4).

5. Results

5.1. Socioeconomic inequality

Table 2 presents the model results of the effect of government order on the average travel distance to parks, the average size of accessible parks, and the percentage of visitation to public parks. Specifically, column (1), (3), and (5) show the raw effects of stay-at-home order on the key dependent variables. Column (1) and (3) generally indicate that people may visit public parks at a longer distance but with a larger area. It might be because under the stay-at-home policy people were more likely to visit public parks with low population density for a lower risk of infection. Column (5) implies that more people would go to public parks during the pandemic, confirming our primary assumption based on the existing studies [e.g., (4)].

Column (2) indicates that the elderly, non-college-educated people, and people in poverty status would generally visit parks near their homes. It might be due to their low mobility as many of these people have limited transportation options. The pandemic lockdown further exacerbated such green space inequalities for these marginalized groups when the public transportation systems were either closed or restricted. However, blacks appeared to travel longer for park visits. It might be because blacks have long suffered from spatial inequality in terms of limited access to free public parks that, in turn, forced them to travel longer distances for parks. For unemployed people, they could travel a long distance to a park without extra concern about the commuting time because of no work obligations.

In column (4), the decrease of the average area further confirms our explanation for the decreasing travel distance of the elderly, non-college-educated people, and poor people, because they mainly prefer nearby small parks than distant large parks. Moreover, unemployed

TABLE 2 Before and after stay-at-home order.

	Distance		Size		Percentage of visitation	
	(1)	(2)	(3)	(4)	(5)	(6)
Order	0.001*** (0.0003)	0.030*** (0.012)	0.003*** (0.0003)	0.045*** (0.011)	0.076*** (0.002)	0.946*** (0.008)
Order × elderly		−0.018** (0.002)		−0.005*** (0.0017)		−0.005*** (0.001)
Order × no college degree		−0.038*** (0.015)		−0.054*** (0.013)		−1.104*** (0.010)
Order × poverty		−0.011*** (0.003)		−0.010*** (0.002)		−0.070*** (0.002)
Order × unemployment		0.009*** (0.002)		0.008*** (0.002)		0.045*** (0.001)
Order × black		0.018*** (0.002)		−0.004*** (0.002)		−0.023*** (0.001)
Census tract fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Date fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,073,800	1,073,800	1,073,800	1,073,800	1,073,800	1,073,800
R-squared	0.37	0.37	0.50	0.50	0.70	0.71

$p < 0.01^{***}$; $p < 0.05^{**}$.

people are more likely to visit larger parks since they could travel a longer distance. However, even though blacks could travel a longer distance, they still could go to a smaller park. It could be because some large parks, such as state parks or national parks, require parking fee or entrance fee, while smaller park is free to access and park. It could also be that blacks have concern that they would be discriminated in large parks where the white people are interested in Gobster (28). That is, blacks might not choose to visit a larger but farther park for a lower risk of infection because they generally show less trust in science during this particular pandemic (40, 67).

Column (6) indicates that the elderly and non-college-educated people may reduce their visitations to public parks during the lockdown. The elderly is knowingly the most vulnerable population group amid this pandemic so that they would be more cautious about potentially contracting the virus. Furthermore, non-college-educated and low-income people are less likely to have stable work, which could be worsened by COVID-19, leading them to have less free time for leisure. Further, it has been widely acknowledged that low-income people might not be able to afford admission fees of public parks so that they would travel long distances to visit free parks. Likewise, blacks would also have less chance to visit parks because they are more likely to be in poverty status and usually suffer from poor transport mobility. Interestingly, unemployed people appeared to increase their visits to public parks during the lockdown. This might be explained by the extra free time they had without work obligations so that they would be more willing to visit farther public parks when the majority of public spaces had been restricted.

Supplementary Table 1 shows the effects of socioeconomic and demographic variables using data in 2019 and 2020 to reduce the bias of the seasonal difference. The results still support our earlier findings from Table 2, thereby further demonstrating the robustness of our analysis.

5.2. Urban-rural inequality

Table 3 indicates the results from the analysis of examining the comparative effects of the urban and rural areas on people's access to public parks. Column (1) shows that people living in metro areas would travel a longer distance to public parks than people in non-core areas (i.e., rural areas in this study) after the issuance of stay-at-home orders. As confirmed in column (2), it could be because people in urban areas would be more likely to visit larger parks with more space to exercise public health measure and thus face a lower risk of infection, despite that the coefficient estimates are not statistically significant for small metro areas and micropolitan areas. As shown in column (3), people in the metro areas would be more likely to visit public parks compared to the rural areas. It is worth noting that with the area being more populated, the coefficients for increased distance and increased percentage of visitation would be greater, suggesting that green space inequality was worsening in less populated areas. Again, we examined the urban-rural disparity using the data in 2019 and 2020 and our findings are still robust (Supplementary Table 2).

5.3. Mobility inequality

Table 4 shows the model results about the effects of mobility on green space access. Surprisingly, column (1) indicates that households with more vehicles would increase the average distance traveled to public parks after the stay-at-home order, except that the coefficient estimate of Four Or More Vehicles Available is not statistically significant. Furthermore, it also suggests that when the density of transit stops increases people in the neighborhoods would travel a long distance to visit public parks. Column (2) indicates that the availability of vehicles might not impact people's choice for the size of the parks. However, a higher density of transit stops would

TABLE 3 Urban–rural disparities before and after stay-at-home order.

	(1) Distance	(2) Size	(3) Percentage of visitation
Order	−0.126*** (0.008)	−0.0122* (0.007)	0.003*** (0.001)
Order × large central Metro	0.174*** (0,008)	0.024*** (0.007)	0.175*** (0.005)
Order × large fringe metro	0.147*** (0.008)	0.027*** (0.007)	0.044** (0.005)
Order × medium metro	0.114*** (0.008)	0.021*** (0.007)	0.040*** (0.005)
Order × small metro	0.058*** (0.009)	−0.007 (0.008)	0.011* (0.006)
Order × micropolitan	0.051*** (0.009)	0.003 (0.008)	0.004 (0.006)
Census tract fixed effects	Yes	Yes	Yes
Date fixed effects	Yes	Yes	Yes
Observations	1073,800	1073,800	1073,800
R-squared	0.37	0.50	0.70

$p < 0.01^{***}$; $p < 0.05^{**}$; $p < 0.1^{*}$.

TABLE 4 Mobility disparities before and after stay-at-home order.

	(1) Distance	(2) Size	(3) Percentage of visitation
Order	0.004** (0.002)	0.005** (0.002)	0.074*** (0.002)
Order × one vehicle available	0.018*** (0.003)	0.010 (0.008)	0.039*** (0.002)
Order × two vehicles available	0.010*** (0.002)	0.003 (0.002)	0.064*** (0.001)
Order × three vehicles available	0.017*** (0.003)	0.0002 (0.002)	0.069*** (0.001)
Order × four or more vehicles available	0.0003 (0.002)	−0.001 (0.002)	0.030*** (0.001)
Order × density of transit stops	0.015*** (0.002)	0.006*** (0.001)	0.051*** (0.001)
Census tract fixed effects	Yes	Yes	Yes
Date fixed effects	Yes	Yes	Yes
Observations	1,143,236	1,143,236	1,143,236
R-squared	0.37	0.50	0.70

$p < 0.01^{***}$; $p < 0.05^{**}$.

enable people to visit a large public park, again, where the infection risk is lower. Column (3) shows that the increase in household car ownership would in turn increase the visitation to public parks even during the pandemic. Similarly, the increasing provision of transit stops would also lead to more park visits.

The results are generally consistent with the conventional wisdom that mobility-rich neighborhoods are more accessible to green spaces (68). Thus, mobility-poor neighborhoods should be given more attention during the pandemic, considering that they generally have limited access to public parks and could thus significantly suffer from the resulting social and physical isolation. Furthermore, choosing to drive to public parks during the pandemic has many benefits, especially driving alone or driving with household members, because people do not have to contact strangers as they would through transit. Again, the results are also validated by using the data of 2019 and 2020 (Supplementary Table 3).

6. Discussions

This research sheds light on landscape planning and public health management through the lens of green space justice during a global pandemic. Equal access to green spaces has long been advocated for just spatial planning, but the existing class division has seemed to widen the injustice gap with respect to public park access due to this pandemic. For instance, inequalities in park acreage and distance are evident across American communities. However, planning does not operate in a wonderland with utopian blueprints coming into fruition, while it indeed is as much as a political process as an economic and social one. The most challenging in practice is certainly balancing the competing interests among the different stakeholders such that the government has to acquire significant amounts of parkland, partner with various agencies, and require developers to include parkland in their subdivisions, whereas the developers aim to minimize such public good investments to maximize their profits (14).

Negotiations will follow and compromises will be made, but our results clearly show that there is still large room for improvement to close the gap of green space inequality in the US. Local governments could link their park systems to neighborhoods with similar socioeconomics and demographics, population, and mobility resources during the planning process to uncover some specific issues within local park systems, such as park deserts, and help them prioritize future investments. Lowering the admission fee and offering safe transports to public parks might also be more feasible for socially vulnerable communities during COVID-19 because these do not necessitate the acquisition of new parkland. We urge policymakers to integrate green space justice into the spatial organization of public parks because guaranteeing people's access to public parks has seldom to be a central component of the urban sustainability agenda (69, 70). Urban neoliberal policies have resulted in a global surge in the privatization of green space (71). While revenues from private business interests (e.g., cafés, stores) make park restoration and management financially sustainable, it occurs at the expense of public green space and the exclusion of disadvantaged groups, which is especially evident amid the pandemic.

Our results suggest that public health practitioners and researchers should pay more attention to park-poor neighborhoods, particularly the aging neighborhoods, low-income neighborhoods, black neighborhoods, and mobility-poor neighborhoods, during and after this pandemic. Access to public parks is essential for vulnerable populations because these socially marginalized groups of people would suffer even more, e.g., server anxiety, due to physical isolation (2). Regional agencies could also pay more attention to rural residents where access to public parks seem to not be adequate amid the pandemic. For neighborhoods with low availability of private vehicles, policymakers could offer interim mobility services. For

instance, during the city lockdown, transit agencies could continue the operation of public transit that connects public parks and vulnerable neighborhoods, requiring public transit users to wear face coverings or masks and practice social distancing.

This study can be improved by addressing the following limitations. First, we only focused on the distributive justice of public parks. That is, subsequent studies could analyze procedural justice and interactional justice during COVID-19 using more evidence. Second, we adopted the mobile phone location data that may not exhaustively represent some underrepresented groups such as the elderly, poor people, and non-college-educated people, who might not own a smartphone or use it frequently. Future research should use some pilot study areas to further test the validity and robustness of this dataset. Third, due to the computation-intensive analysis of all neighborhoods in the contiguous US, spatial dependency cannot be considered in our regression analysis. Future studies could select a comparatively small study area to account for the spatial dependency in the analysis. Fourth, the composition of green space in non-urban areas is very complex, including natural grassland, marsh, etc. in addition to public parks, so that our analysis has not comprehensively considered these types of green space.

7. Conclusion

Our study contributes to understanding green space justice during the COVID-19 from the perspectives of socioeconomic and demographic inequalities, urban and rural inequalities, and mobility inequalities. The main strength of this study lies in the comprehensive examination of green space inequality during the pandemic. Another strength is that this research studied all the neighborhoods across United States. Our findings are threefold.

- After the stay-at-home is issued, the elderly, non-college-educated people, and poor people would be more likely to travel a less distance, visit relatively small public parks, and visit public parks less frequently. Blacks could also visit public parks less frequently during the stay-at-home order. Further, we found that unemployed people would increase their visits to public parks because they have more free time and do not have to work during the pandemic.
- Compared to rural areas, neighborhoods in urban areas show significant advantages in terms of visiting public parks more frequently and visit a large park to minimize infection risk.
- Mobility-rich neighborhoods may have better access to public parks, particularly for neighborhoods with more private vehicles available. Even though transit service may be beneficial to people's access to public parks, taking transit buses would further expose people to the virus. Regarding the potential health benefits of public green space, the unequal access to green space may exacerbate health inequalities, particularly during such an unprecedented pandemic. We argue that the government should devote special efforts to park-poor neighborhoods during and after the pandemic.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

SG: conceptualization, writing—original draft preparation, review and editing, and visualization. WZ: methodology, data curation, writing—original draft preparation, and investigation. XF: review and editing, resources, validation, and data curation. All authors contributed critically to the manuscript and agreed to publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1055720/full#supplementary-material

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Developing and testing an environmental economics approach to the valuation and application of urban health externalities

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Background: Poor quality urban environments have substantial impacts on public and planetary health. These costs to society are not readily quantifiable and remain largely external to mainstream measures of progress. Methods for accounting for these externalities exist, but their effective application is in development. Yet there is an increasing urgency and demand given the profound threats to quality of life both now and in the future.

Methods: We combine data from a series of systematic reviews of the quantitative evidence linking characteristics of the urban environment with health consequences and the economic valuation of these health impacts from a societal perspective within a spreadsheet-based tool. The tool–named HAUS–allows the user to estimate the health impacts of changes in urban environments. The economic valuation of these impacts in turn facilitates the use of such data in broader economic appraisal of urban development projects and policies.

Findings: Using the Impact-Pathway approach, observations of a variety of health impacts associated with 28 characteristics of the urban environment are applied to forecast changes in cases of specific health impacts that result from changes in urban contexts. Unit values for the societal cost of 78 health outcomes are estimated and incorporated in the HAUS model in order to allow the quantification of the potential effect size of a given change in the urban environment. Headline results are presented for a real-world application in which urban development scenarios that have varying quantities of green space are evaluated. The potential uses of the tool are validated *via* formal semi-structured interviews with 15 senior decision-makers from the public and private sectors.

Interpretation: Responses suggest that there is significant demand for this kind of evidence, that it is valued despite the inherent uncertainties, and has a very wide range of potential applications. Analysis of the results suggest expert interpretation and contextual understanding is critical for the value of evidence to be realized. More development and testing is needed to understand how and where it may be possible to apply effectively in real world practice.

KEYWORDS

health, environmental economics, decision-making, urban development, planning

1. Introduction

The quality of our urban environments impacts substantially on human and planetary health. Air pollution, lack of access to nature, low availability of healthy food and drink, and inactive lifestyles all contribute to non-communicable diseases (NCD) such as obesity, diabetes, respiratory illness, anxiety and depression. Together these NCDs make up 89% of deaths in the UK, most of which are seen as preventable (1, 2). Socio-economic pressures compound these impacts significantly (3). Climate change may also act as a stress multiplier in urban centers, exacerbating existing problems such as overheating and flooding (4).

Some estimates of economic costs have been made that attribute costs to these risk factors in the urban environment. Though disconnected and overlapping, they do give a sense of the scale of the challenges. For example, income inequality, which is strongly linked to poor quality urban environments through quality of housing and accessibility of green infrastructure, has been estimated to result in productivity losses of £31–33 billion per year (3). A separate estimate suggested low quality property and neighborhoods in England cost the UK National Health Service £1.4 billion annually in treatment provision (5). Obesity, which has multiple risk factors, including obesogenic environments and "food deserts" (i.e., lack of healthy food in a local area), costs an estimated £27bn per year due to its negative effects on productivity, earnings, and welfare payments (2). Costs from climate change are also likely to be very substantial–for example, one estimate suggests it will add £120bn to property insurance costs by 2040 and have adverse impacts on human health through overheating in buildings, storms and flooding (6).

Alongside these estimates of financial costs associated with the urban environment there is a small literature that recognizes the non-market dimension to welfare loss attributable to components of this environment. The use of economic valuation approaches in measuring, and accounting for, non-market environmental and social "goods and services," including human health outcomes, has a substantial history (7). However, its integration in to mainstream decision-making has been slow for a number of reasons, not least the considerable challenge of quantifying intangible aspects of health in welfare terms (8, 9). The exception to this is in the air pollution context–an environmental hazard that is most severe in urban areas where population density is highest. For example, the UK Government estimates average damage costs–including both market- and non-market health costs of air pollution associated with particulate matter, nitrogen dioxide, ammonia, volatile organic compounds and sulfur dioxide (10). These damage costs are disaggregated by rural and urban location, the urban locations being further disaggregated by size of conurbation (11).

This lack of uptake does not appear to imply a lack of appetite for non-market valuation. For example, a series of 30 interviews with senior decision-makers from public and private sectors suggest that there is a strong desire for more comprehensive, approaches to valuation of health in urban areas (10). These interviews highlight a range of potential areas of application, including: government investment programs, land valuation, private sector investment and planning decisions (12, 13).

There currently exist a number of tools that generate quantitative estimates of health impacts that may be expected to result from a local policy or intervention within the urban context. WHO Europe has developed the Health Economic Assessment Tool (HEAT) for assessing changes in cycling and walking provision and patterns, using estimates of reductions in mortality as a benefit of increased active travel (14). The tool uses a Value of a Statistical Life (VSL) to estimate the value of changes to mortality; morbidity is excluded. The ITHIM model, developed in the UK and applied there and in the US, has also been used to estimate the health impacts of transport interventions, using productivity losses and treatment costs of illness to estimate the value of attributable changes to mortality and morbidity (15).

Additional social valuation tools methods that incorporate health impacts have emerged in the UK since the United Kingdom 2012 Public Services (Social Value) Act (16), that has as a legal requirement consideration of wider social, economic and environmental benefits additional to financial profit. These include the UK Social Value Bank (17), the National TOMs framework (18) and the Manchester Cost Benefit Analysis tool (19). Health is typically just one of many outcomes included in these models, such as employment, volunteering, crime and perceptions of local environment. These models do not offer a method for estimating potential changes to health, but rather offer a database of unit values to help policy makers estimate the social value of public sector investment such as neighborhood improvements which may impact on health. Health in these models is defined in terms of self-rated life satisfaction rather than by individual morbidity end-points. For example, unit values are given in terms of episodes of hospital attendance rather than cases of asthma. Mortality is not normally included.

We have created a tool for urban planners which allows the user to consider all determinants of health which relate to new urban housing developments. In doing so, we address gaps identified above in existing tools by estimating and valuing changes to health risk both in terms of morbidity and mortality and address a wide range of environmental determinants of health which have been linked with urban development. We provide a resource of unit costs for 76 health outcomes, disaggregated so that they can be attributed across multiple agencies from a societal perspective.

This study adopts an approach to quantification based on the Impact-Pathway method which uses known pairings in the published literature between individual characteristics of the environment, such as $PM_{2.5}$ air pollution, and specific observed health outcomes to forecast changes in cases of morbidity and mortality resulting from a change in the environment. These health cases can then be monetized and aggregated to estimate the social value of an intervention (20, 21). We extend this approach to a wider range of environmental determinants of health than has been attempted previously. In doing so we utilize the findings of a series of systematic reviews on the quantitative relationships between characteristics of the urban environments and health outcomes, and evidence on the economic welfare valuation of the identified health outcomes (22, 23). The innovation is not in the modeling *per se*, but in the integration of multiple approaches, including: the systematic review of urban-health evidence, an environmental economics approach to valuation of urban health externalities, and the validation of our approach with potential end users.

This paper first outlines the approach taken to express quantitative health impacts of the urban environment in economic terms. We then present indicative findings from an application of the model in the context of an urban regeneration plan in Bristol, UK. We

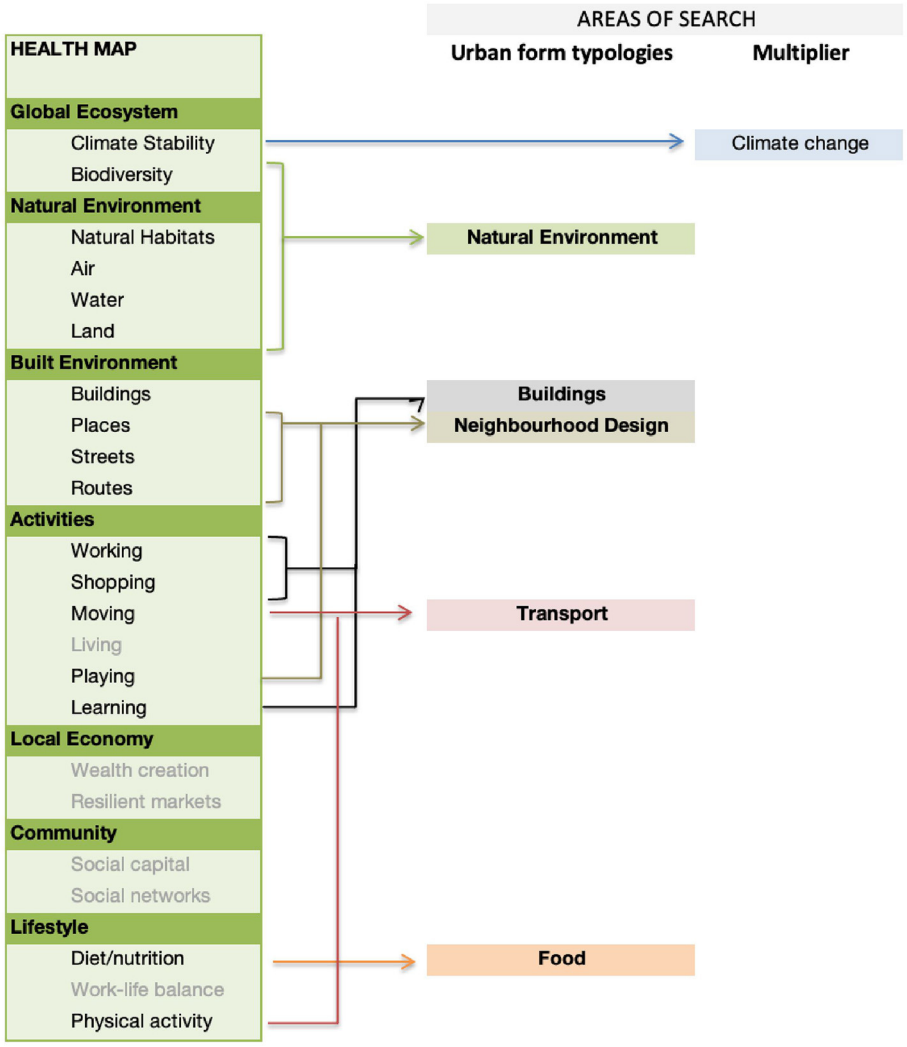

FIGURE 1
Identification of five main search areas (of urban form typologies), derived from the Health Map.

review these findings, reflecting critically on the current limitations to this modeling as well as its possibilities.

2. Methods and materials

2.1. Definition of the urban form elements

In principle, our model is intended to encompass as comprehensive a range of characteristics of the urban environment as possible, thereby ensuring that consideration of any associated impacts on health in decisions relating to urban development are as complete as possible. In order to achieve this the extent was scoped in the first instance by adopting the categories defined by the Health Map, (24), a classification of the health determinants associated with the planning of human settlements published by the Royal Society for the Promotion of Public Health, and offering a comprehensive coverage of socio-environmental issues relating to urban planning and design. This classification was validated against similar classifications assembled in five other checklists including: Public Health England's Topics (25), Vancouver Healthy Toolkit (26), BREEAM Communities (27), HUDU Rapid HIA (28) and Egan Review (29) (see Supplementary material).

We then grouped the 23 aspects of the urban environment in the Health Map into five main "typologies" of urban form (or areas of search): natural environment, buildings, neighborhood design, transport and food; climate change was categorized as a "multiplier" of each element of urban form (Figure 1). Six areas from the Health Map were excluded as they are not explicitly related to elements of the urban form: living, wealth creation, resilient markets, social capital, social networks, work-life balance (as shown in gray in Figure 1).

2.2. Identification of health impacts

We identify the individual health impacts associated with the five urban form typologies on the basis of the systematic reviews previously undertaken that use these classifications (22, 23). From the initial five search areas (Figure 1), the evidence derived through the systematic reviews resulted in a slightly changed list of urban form typologies. Buildings, Natural Environment, Climate Change

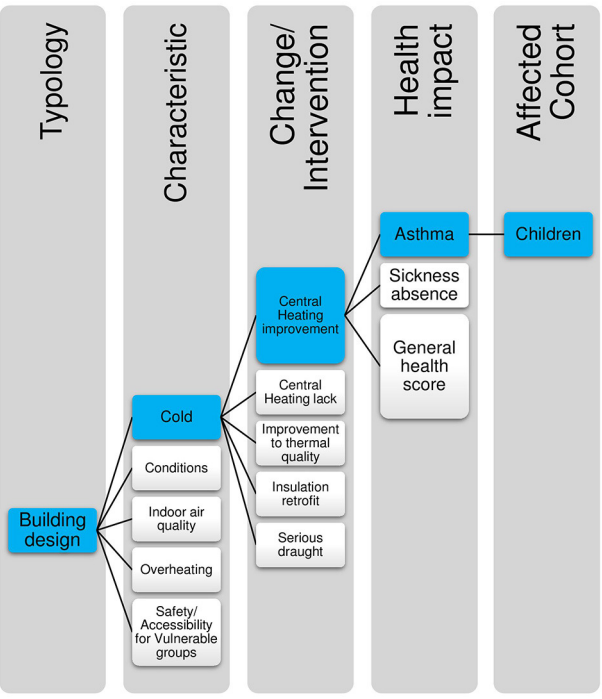

FIGURE 2
Illustration of how impact pathways are defined: highlighted in blue is the specific pathway for central heating improvements and asthma in children.

and Transport remain the same, but Neighborhood Design and Food are combined into Community Infrastructure, and we use an extra category of Socio-economics to include elements such as affordability, living in areas of high poverty and renting vs. home ownership.

We understand health impacts to include mortality and non-communicable disease, including physical and mental illness, congenital deformities, injuries from road traffic and domestic accidents, loss of physical functioning and limits to daily activities, symptoms of illness such as wheezing, behaviors such as activity or diet, mental illness, obesity, and measures of wellbeing such as life satisfaction scores. We also include upper and lower respiratory tract infections, including colds and flu. We do not include dental problems, sexually transmitted disease, memory problems, educational attainment, or injuries from assault, all of which are less directly associated with the elements of the urban form that we have identified.

The epidemiological literature reported in the systematic reviews (22, 23) allow us to identify 170 urban environment characteristic-health impact pathways that observe a causal path from a specific environmental change (such as air pollution or increased green space) to a health outcome (such as increased risk of asthma or diabetes). These are listed in the Supplementary material. An example of one such pathway is presented in Figure 2.

Impact pathways are defined here as estimates of the magnitude of effect that a specific change within a single characteristic of the urban environment may have on a specific health outcome. These impact pathways are defined by the specific parameters from the original source study or studies, and include detail of the specific environmental change, the size and scale of the effect, the population demographics of the original study, and the individual health outcome. Where multiple pieces of evidence exist relating to the same environmental feature and the same health outcome, for example in levels of $PM_{2.5}$ in air and asthma in children, data was selected on the basis of strength of evidence, robustness, and applicability to the specific UK housing context.

Evidence for change defined in the impact pathway is expressed in the form of dose-response; i.e., for a specific change in environmental characteristic, a quantitative measurable change in health status is observed as a change in the risk (known as "odds") of illness. The epidemiological evidence is primarily described in terms of linear relationships. We judge that, given the wide range of real-world contexts, this is unlikely always to be the case. Consequently, our model outputs should be regarded as approximations of the size of health changes associated with changes in the urban environment.

In the HAUS model the aim is to identify environmental changes at an intervention specific level, so that it is possible to compare the efficacy of alternative interventions. Impact pathways are highly specific, replicating the individual parameters of the original study. For example, Figure 2 indicates how the impact pathway of Central heating improvements > asthma in children sits within the typology of Building Design and the Characteristic of Cold.

2.3. Specification of the model

In this paper we develop an economic tool that enables stakeholders to quantify the impact on population health of a specific intervention or policy relating to the environment in urban environments.

The tool is known as the Health Appraisal for Urban Systems tool (or HAUS for short). HAUS has three key features:

- It synthesizes the available evidence to allow policy makers to access data on measurable, quantifiable changes to health which have been associated with the urban environment;
- It enables users to estimate the potential magnitude of impact which a specific intervention may have on the health of residents;
- It offers a method for valuing these health impacts, for use in cost-benefit, or cost-effectiveness analysis of alternative projects, policies or other intervention forms.

It is therefore intended for use as a tool to support scenario appraisal and to inform broader conversations around prioritization in health in urban development. The HAUS tool covers non-communicable disease in all populations in the UK, including older adults and children–categories not disaggregated within existing tools.

It is capable of estimating effects at the neighborhood scale, and can be extended to take into account different population sizes impacted but is not designed to be used to estimate effects on an individual or a single family group.

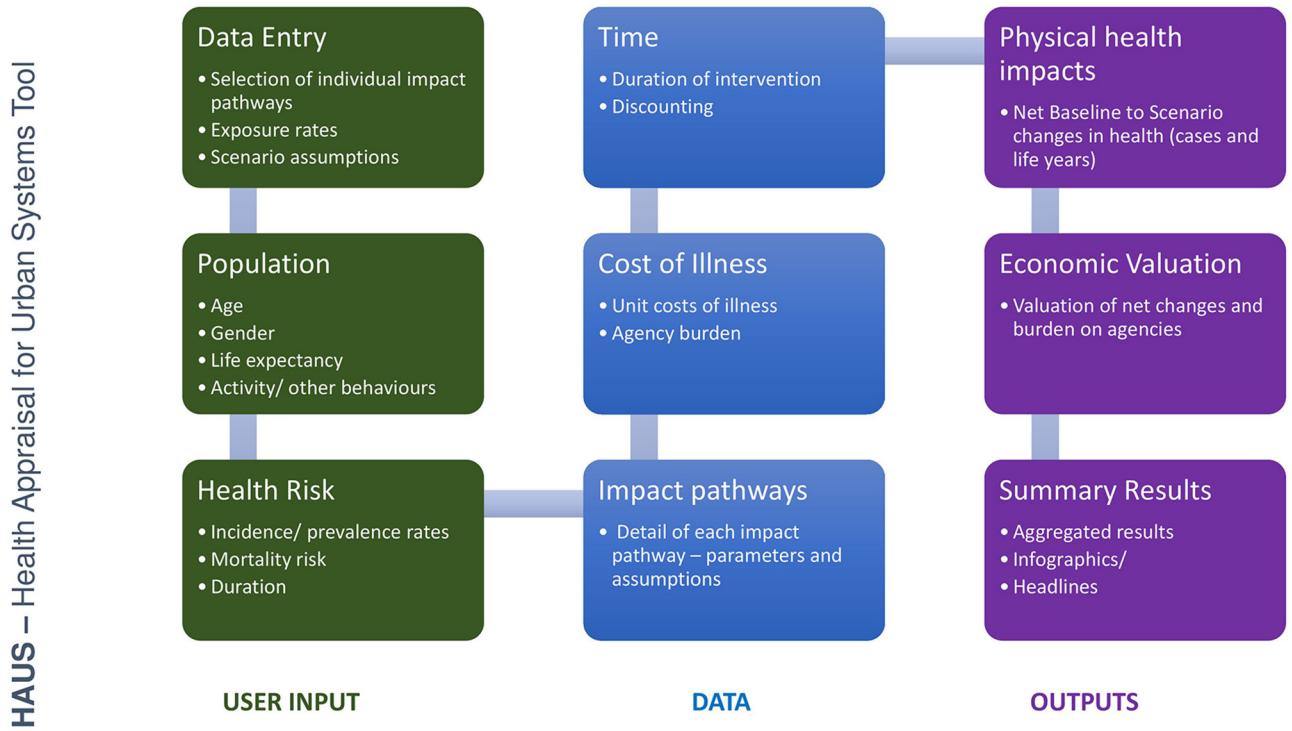

FIGURE 3
Illustration of the structure of the Health Appraisal for Urban Systems (HAUS) tool.

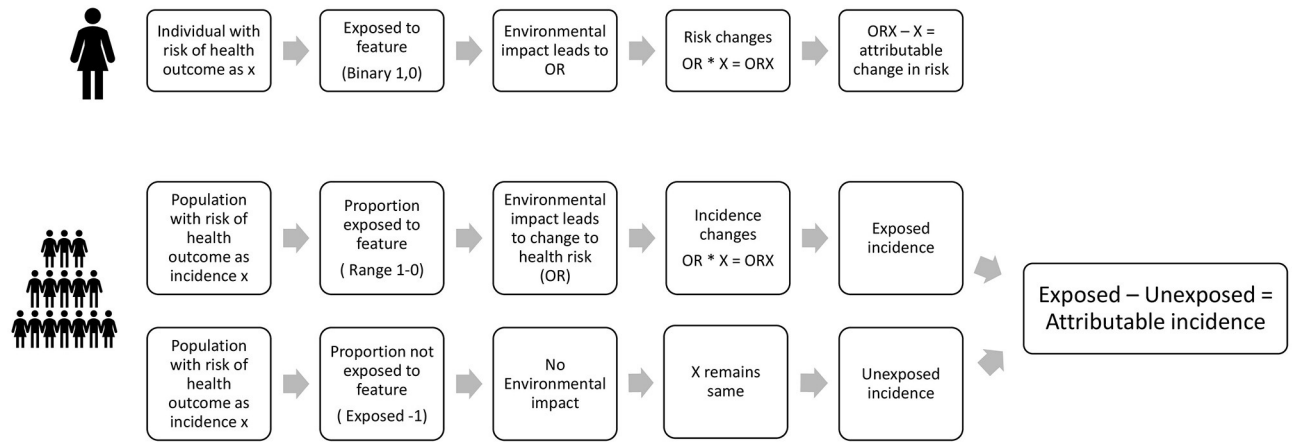

FIGURE 4
Estimation of attributable changes in health in HAUS for an individual and for a population.

2.4. Structure of the health appraisal for urban systems tool

The HAUS tool is initially a spreadsheet-based system, for ease of use and software availability, created in Excel software (30). The structure of the tool is set out in Figure 3.

The tool includes the following:

- User input sheets: allowing the user to identify key assumptions around each scenario for assessment, such as population size and level of exposure to each specific environmental feature. In the absence of user-defined data, the tool specifies default settings for a given population.
- Data sheets: Data on demographic profile of the affected population, individual health end-point risk, and unit costs of illness.
- Outputs: Detailed comparisons of results and valuations of health impacts, and a dashboard which allows the user to quickly identify headline information.

The estimation process undertaken within the HAUS tool is illustrated in Figure 4. We present health impacts in terms of

estimated attributable changes to cases of illness, deaths, years of illness and years of premature life lost.

These are derived in the following way:

Each individual has an existing risk of contracting a particular illness, for example, asthma, or diabetes. We assume that if they are exposed to a change in environmental conditions, this may alter their odds, or risk, of contracting that disease. The difference between their original risk of disease, and the new odds of the disease is the amount of risk which can be attributed to the environmental change. This principle is applied in the same way to a whole population likely to be impacted by the change–the population being defined in the impact-pathway specification. Estimation of the risk of being affected by the illness in question (e.g., asthma, diabetes, etc.) is therefore made in relation to the baseline, i.e., the existing incidence rate of the illness in the population. When part of the population is exposed to a change in environment, we measure the attributable change in incidence by comparing the incidence in the exposed population to the incidence in the unexposed population.

In the HAUS tool, we therefore apply changes in odds or risk of disease which have been observed in the epidemiological literature as being significantly associated with a change in a specific environmental characteristic, or feature, to the exposed population. This method can be delineated more precisely using a notational system, described here for mortality and morbidity respectively.

2.5. Estimation of mortality effect

We calculate mortality in terms of two metrics: numbers of attributable deaths (*Dattributed*) and attributable premature years of life lost (*YLLattributed*). Deaths and premature life years lost here are defined as statistical lives and statistical life years lost–representing the sum of many small numbers of risks of life lost, rather than individual people.

2.5.1. Estimation of attributable deaths

We assume that the annual expected number of deaths in a given population (*De*) can be calculated by multiplying the number of people in the intervention area *(n)* by an average annual mortality rate (*MRlit*) in the baseline literature, e.g., national demographic statistics. We then estimate the proportion of the number of people exposed to a hazard as *Pe* and the number of unexposed people as *Pu,* i.e., *(1-Pe).*

We assume that the mortality rate for the exposed populations is affected by the odds ratio, *OR,* associated with the hazard so that *MRe* = (*MRlit***OR).* The OR is derived from the specific impact pathway. The following conditions therefore hold:

$$MRu = MRlit$$
$$MRe = MRlit^{*}OR$$
$$Pe = ne/n$$
$$Pu = 1 - Pe$$
$$De = MRe^{*}(n^{*}Pe)$$
$$Du = MRu^{*}(n^{*}Pu)$$
$$Dattributed = (De + Du) - Du$$

where:

MRlit = mortality rate in the assessed population derived from literature (for a specified age range)
MRe = mortality rate in the exposed population
MRu = mortality rate in the unexposed population
OR = Odds Ratio for change in mortality derived from Impact-Pathway
n = the population assessed in HAUS
ne = the number of exposed people in the population
nu = the number of unexposed people in the population
Pe = Proportion of the assessed population that is exposed
Pu = proportion of the assessed population that is not exposed
De = deaths in the assessed population with exposure
Du = deaths in the assessed population without exposure
Dexpected = expected deaths in the population
Dattributed = deaths attributed to the exposure assessed in HAUS.

2.5.2. Estimation of attributable life years lost

We calculate the number of preventable life years lost (*YLL*) as following:

Life years (*LY*) are the sum of the expected years of life in the sample population *n*.

(This is calculated on the basis of: *n* in each age year * life expectancy for each age year).

Premature life years lost attributed to the exposure (*YLLattributed*) are calculated on the basis of average Life Years ($\overline{LY}$) multiplied by the number of deaths estimated in the exposed and unexposed populations.

Attributable premature years of life lost: *YLLattributed = YLLe–YLLu*

$$LY = \sum_{i=1}^{n} LE$$
$$\overline{LY} = \frac{LY}{n}$$
$$YLLe = \overline{LY}^{*}De$$
$$YLLu = \overline{LY}^{*}Du$$
$$YLLattributed = YLLe - YLLu$$

where:

LE = life expectancy in years for each age group in the population
LY = Sum of life expectancy in years
$\overline{LY}$ *= Average life expectancy in years*
De = deaths in the assessed population with exposure
Du = deaths in the assessed population without exposure
YLLe = years of life lost in the assessed population with exposure
YLLu = years of life lost in the assessed population without exposure
YLLattributed = years of life lost attributed to the exposure assessed in HAUS.

2.5.3. Estimation of morbidity effect

We estimate morbidity effects in terms of two metrics: attributable cases of illness (*Cattributed)* and years with illness (*YLDattributed*).

2.5.3.1. Estimation of attributable cases of illness

We assume that the expected number of cases of illness in the population (*Cexpected*) can be calculated by multiplying the number of people in the intervention area (*n*) by an incidence rate (*IRlit*). We again forecast the proportion of the number of people exposed to a hazard as *Pe* and the number of unexposed people as *Pu (1-Pe)*. We assume that the incidence rate for exposed populations is determined by the odds ratio associated with the hazard *OR* so that *IRe = (IR*OR)*.

Cases Exposed $Ce = (n*Pe)*(IRe)$
Cases Unexposed $Cu = (n*(1–Pe))*IRu)$

Attributable cases of illness: $Cattributed = (Cu+Ce)-Cu$

$IRu = IRlit$
$IRe = IRlit*OR$
$Pe = ne/n$
$Pu = 1 - Pe$
$Ce = IRe * (n*Pe)$
$Cu = IRu * (n*Pu)$

where:
IRlit = Incidence rate in the assessed population derived from literature (for a specified age range)
IRe = Incidence rate in the exposed population
IRu = Incidence rate in the unexposed population
OR = Odds Ratio for change in risk of illness derived from Impact-Pathway
n = the population assessed in HAUS
ne = the number of exposed people in the population
nu = the number of unexposed people in the population
Pe = Proportion of the assessed population that is exposed
Pu = proportion of the assessed population that is not exposed
Ce = Cases of illness in the assessed population with exposure
Cu = Cases of illness in the assessed population without exposure
Cexpected = Cases of illness expected in the population
Cattributed = Cases of illness attributed to the exposure assessed in HAUS.

2.5.3.2. Estimation of attributable years spent with illness

We calculate the number of years with illness or disability (*YLD*) based on the sum of years of life expectancy (*LE*) in the sample, and the expected duration of the illness (*Tsick*) capped with Life Expectancy (*LE*) so that *Tsick* cannot exceed *LE* for any individual:

Attributable years lived with illness $YLDattributed = Cattributed*YLD$

$$YLD = \sum_{i=1}^{n} \begin{cases} Tsick\ if\ Tsick > LE \\ LE\ if\ Tsick < LE \end{cases}$$

where:
YLD = Sum of years of life spent with illness or disability (or remaining life expectancy) in population affected by the illness
LE = Life expectancy in years for each age group in the population
Tsick = Average duration of a case of illness, derived from the literature
YLDattributed = years of illness attributed to the exposure assessed in HAUS.

2.5.4. Estimation of time effects

We calculate the sum of attributable cases or deaths over time applying the number of years of the project as a simple linear multiplier, assuming that mortality rates, morbidity incidence rates and risk ratios are linear and do not change over time.

The total effect of an intervention (*Total effect)* over the duration, *Tintervention,* is therefore as follows:

$$Total\ Effect = Tintervention* \begin{cases} Dattributed \\ Cattributed \end{cases}$$

We assume that there is a lag between a change in environment and full health effect of 5 years, so that in the first year only a 20% of the full effect is estimated, 40% in the second year, and so on, increasing by 20% each time. The total effects are also capped, so that we only include health effects expected within the lifetime of the project, set at 25 years.

Life expectancy data and population demographics are derived from Office of National Statistics statistical datasets for the reference year 2019 (31).

Information on disease incidence rates and mortality rates were derived from a number of sources, including mortality data from the Office for National Statistics (32), Hospital Episode statistics from NHS Digital (33), and specific disease incidence from the Global Burden of Disease Study (34). Information on wellbeing and mental health, activity levels and other behaviors are derived from the Health Survey for England (35).

Wherever possible, incidence rates are identified as relating to the UK population for 2019, but where UK data has not been available we have referred to data for England.

2.6. Estimation of value of health impacts

Economic appraisal is an integral part of decision making when policy makers seek to find the most efficient use of resources. Rooted in welfare economics, economic appraisal attempts to define whether a project makes a net contribution to social welfare. At its heart are methods for quantifying and valuing changes to individuals' utility as a result of a change in health, so that these values can be used in cost-benefit analyses, for example. In this paper we value health impacts from the societal perspective, taking into account the impact of health on the individual, their family, employers, healthcare providers and the state. This approach incorporates different components of the welfare costs of illness, including direct medical and paid care expenses, indirect lost opportunity costs such as productivity and the value of informal care time, as well as a value which monetises the disutility or pain and suffering associated with disease.

The HAUS model estimates the monetary equivalent of the disutility relating to a loss of welfare associated with risks of premature death and illness. Disutility is expressed as an individual's Willingness to Pay (WTP) to avoid illness or for improvement in health and is assumed to be the sum of the observable cost of illness (lost wages and mitigation costs) and the monetary equivalent

of the non-observable cost of lost utility (mortality, pain and suffering). These non-observable costs are estimated using non-market valuation methods.

Society has mechanisms for shifting many costs of illness away from the individual–i.e., *via* medical insurance and sick leave policies (36). This is particularly relevant for the UK, where most healthcare is free at the point of use. We attempt to define the societal impact of changes to health status across a population and identify where the burden of costs of illness falls. In the process of doing so, we utilize data from a range of sources including the published literature on non-market values. In this instance value transfer methods are adopted to ensure that value estimates derived in the context of previous studies are adjusted to reflect their transfer to a different context.

In order to estimate the value of identified changes in health in each impact pathway we multiply the unit values calculated for each specific health impact by the attributable health impact.

Unit values for morbidity impacts are estimated per year of ill health and per case of illness whilst unit values for mortality are estimated as the Value of a Statistical Life (VSL) and the Value of a Statistical Life Year (VSLY).

A library of reference values relating to direct and indirect costs and disutility derived from primary studies was estimated using a systematic review approach, using meta-analysis, benefits transfer techniques and quality assessment to derive reference values and ranges from the primary and secondary evidence base.

A systematic review of published literature was carried out, with additional modeling to estimate unit values for the range of health impacts included in our HAUS model. Electronic sources for peer-reviewed literature were searched, followed by reference searching. Studies were included that had clearly stated methodologies, were written in English, and which could be utilized in a UK context. The search prioritized studies from 2016 to 2020, which estimated values at an individual, per annum or per case level. Reference unit values are estimated for 76 individual health outcomes, including physical and mental illness, mortality, and health related behaviors, such as activity, obesity, and alcohol misuse.

Unit values are estimated for each health outcome in GBP £2019 (Supplementary Table 2). 2019 has been chosen as the reference year for health impacts because of the significant changes to the experience and recording of health since the COVID-19 pandemic began in the UK in March 2020. For example; we know that during this period unusual patterns occurred in expected mortality and hospital admissions, and lockdown restrictions were put in place which affected normal active behaviors (31). This may mean that data for 2020 and 2021 are atypical for use in forecasting future trends of health.

3. Results—Development and testing of the HAUS model

The methodological approach outlined above and informing the HAUS model has so far been tested with external practitioners in two ways: (i) by presenting illustrative findings as part of a number of interviews with public and private sector decision-makers, and (ii) *via* use of the model with case study partners, focusing specifically in the first instance on green infrastructure (this second part forms part of a wider exercise developing valuations across the full range of typologies above).

3.1. Interviews overview

Two rounds of semi-structured interviews were undertaken with 15 senior decision-makers from a purposive sample of the UK's main urban development delivery agencies, both public and private. Methods and findings from the interviews are to be found in separate papers (12, 13). Engagement at senior level with those who have control over key aspects of planning and development implementation—such as land disposal, investment, development delivery and planning permission—was central to the approach. Field notes of the interviewee responses to four questions on the economic valuation are included in the Supplementary material, and summary reflections provided below.

3.2. Case study: Frome Gateway regeneration site, Bristol, UK

3.2.1. Background

Frome Gateway is a 14.7 hectare site in the center of Bristol. The site has been designated a strategically important site in need of major regeneration by Bristol City Council (37). A map of the site can be seen on the Bristol City Council website for Frome Gateway (38).The draft Local Plan set out the ambition for the site to be developed as a new mixed-use neighborhood, including around 1,000 new homes, improved access to the River Frome and existing green spaces, improved connectivity to the site generally, and improved opportunities for work and leisure (37).

HAUS was used to provide detailed information on expected health outcomes related to the scenarios under development and so to increase knowledge about the potential for environmental impacts on health. The specific objectives for evaluating the impact of changes to parks and green spaces includes the following:

1. To identify the health benefits of the parks and green spaces in Frome Gateway in a future scenario, compared with present day and alternative scenarios.
2. To identify the health benefits of providing a specific amount of additional green space in a single large unit, such as a new park.
3. To ascertain whether the same benefits as in (2) can be realized by dispersal of additional green space across the site, such as a series of small pocket parks.

3.2.2. Parameters and scenario building

In order to provide comparative information, four scenarios were developed presenting alternative patterns of development for the site:

3.2.2.1. Baseline scenario: Present day conditions

We assume that the existing quality, condition and area of green space, including the parks and river areas, are as the present day. The site has 2.37Ha of green space mostly contained within two parks: Riverside Park and Peel Street Open Space (39).

3.2.2.2. Definition of future scenarios

1. Scenario 1: (Policy Compliant) improvements in quality of green spaces and 0.31 Ha additional green space consistent with minimum policy ambitions (37).
2. Scenario 2: Future Scenario (single open space): one additional large green space of around 1 Ha dimension, in addition to the provision of green space in Scenario 1.
3. Scenario 3: Future Scenario (dispersed open space): As Scenario 2, but green space provided by a series of small pocket parks (defined as spaces under 0.5Ha in dimension).

A project lifetime of 25 years is assumed. Effects are estimated for an area including a buffer of 300 m around the perimeter of the site, which is used to take into account effects on local communities.

3.2.3. Data

Information on Green Infrastructure was derived using Natural England's Green Infrastructure Framework Map tool (40). The Normalized Difference Vegetation Index (NDVI) score for the site is assumed to be 0.15, with the NDVI for Riverside Park estimated at 0.29. NDVI is used as a measure of exposure to greenness in several of the health studies used in HAUS. NDVI uses satellite imagery to estimate the greenness of an area, with higher scores on a range of −1 to 1 indicating higher levels of greenness. NDVI can be useful as a way of determining the proximity of different types of vegetation, such as grass and trees (41).

Assumptions around environmental conditions are derived from the Development Assumptions Report, technical reports and local site visits (39, 42). Local residents' perceptions of the area, activity levels and usage of parks/open spaces were not known, so a survey of 108 residents living near to the site was carried out in 2022. The survey results provided input to the HAUS model and further contextual information for the regeneration team.

3.2.4. Population

The total affected population, including those within 300 m of the site, is estimated at 9,241. We assume 3,000 residents live within the site boundary in all scenarios. This is based on the provision of around 1,000 new homes with an average occupancy of 2.5 per household, plus an additional 500 student residences.

At present only a small number of homes are present within the site boundary. For easier comparison, the baseline scenario adopts a hypothetical 3,000 residents, reflecting the projected population size in the future scenarios.

3.2.5. Results

3.2.5.1. Health benefits of green space at Frome Gateway: Baseline

The results for the baseline indicate that the existing green space are likely to provide a range of health benefits, especially for adults using the parks who are found to experience reductions in diabetes and reduced risk of weight gain. These are shown in Tables 1, 2. There may, however, be a negative effect from green space on risk of asthma in children, deriving e.g., from pollen: from 8 expected cases in this age group, we estimate a potential increase of 5 attributable cases per year.

TABLE 1 Attributable morbidity affected by green space−baseline.

Characteristic	Environment change[a]	Health outcome	Population	*N*	Cases expected[b]	Baseline cases[c]	% change
Green space	NDVI increase	Cancer (mouth and throat)	Adults > 18	6,927	2	0	0%
Green space	NDVI increase	Respiratory (asthma)	Children < 7	1,223	18	0	0%
Green space	NDVI increase	Weight gain	Children 9–12	583	216	0	0%
Green space	Proximity to green space	Respiratory (asthma)	Children 9–12	583	8	5	60%
Green space	Size of public open spaces	Diabetes	Adults >18	6,927	41	0	0%
Places to play	Park use	Diabetes	Adults >35	3,262	20	−3	−15%
Places to play	Park use	Weight gain	Adults >35	3,262	979	−127	−13%
Total				9,241			

[a]Specific environment related intervention, asset or hazard).
[b]Cases expected in same population per annum without any environmental pathways applied.
[c]Baseline refers to net cases in present day scenario (Attributable cases of morbidity per annum minus expected cases).
Red highlighted text denotes deterioration in health. Green text indicates improvement in health.

TABLE 2 Attributable activity, general health and wellbeing affected by green space–baseline.

Characteristic	Environment change[a]	Health outcome	Population	*N*	Cases expected[b]	Baseline cases[c]	% change
Green space	Proximity to green space	Activity	Adults > 18	6,927	4,295	2,632	61%
Green space	Proximity to green space	Mental health	Adults > 65	588	463	125	27%
Green space	Proximity to large, attractive, open space	Activity	Adults > 18	6,927	3,671	1,432	39%
Green space	Quality of green space (pleasantness)	Life satisfaction	Adults > 65	588	463	125	27%
Green space	Quality of green space (safety)	Life satisfaction	Adults > 65	588	463	125	27%
Places to play	Park improvements	Park use	Men > 18	3,616	2,134	-	0%
Total				9,241			

[a]Specific environmental change, intervention, asset or hazard).
[b]Cases expected in same population per annum without any environmental pathways applied.
[c]Baseline refers to net cases in present day scenario. (Attributable cases per annum minus expected cases).
Green cells indicate health improvement.

3.2.5.2. Health benefits of green space at Frome Gateway: Future scenarios

The potential changes to health in cases under each scenario are compared in Table 3.

Improvements to park quality and safety are assumed to lead to increased park use in all scenarios: this has benefits in terms of reduced risk of diabetes and weight gain.

Scenarios 1–3 indicate a possible increase in NDVI which may lead to reduced risk of mouth and throat cancer. Scenarios 2 and 3, which have the largest potential for increases in NDVI score, indicate potential reductions in risk of being overweight or obese for children.

Greenness, estimated *via* NDVI, may continue to have an impact on increased risk of asthma in children, and this effect is seen in higher values for Scenarios 2 and 3 where there is the most potential for higher NDVI scores.

Health outcomes such as activity, wellbeing and life satisfaction identified in the baseline scenario are not shown to change under the three future scenarios, indicating that the threshold for these is already met by the existing provision of green space.

3.2.5.3. Provision of a large park vs. small pocket parks

Only one change is unique for Scenario 2 compared with the other scenarios, and that relates to an increase in the size of public open spaces. The relevant impact-pathway is found to relate to cases of diabetes and has a specific threshold value of 0.7 hectares. In Scenario 2, the specific provision of an additional park of around 1 hectare unlocks this pathway, potentially leading to a reduction in 10 cases of diabetes from a baseline of 41 cases in the population considered here. Over 25 years, this could lead to savings in health valued at around £22.7 million. In Scenario 3, where additional green space is dispersed across the site, this threshold is not reached and these benefits are therefore not realized.

3.2.5.4. Valuation of health effects over the lifetime of the project

Figure 5 indicates the potential value of attributable changes to morbidity by individual impact-pathways related to green space. This is the sum of the value of changes in years of illness over 25 years under each of the scenarios.

It may be helpful to summarize the total value of health changes by scenario: the figures below have not been adjusted for double counting, but to sum the total effect of each scenario in turn may help indicate the magnitude of the difference between them:

- Scenario 1 (Policy Compliant) is estimated to improve morbidity to a value of around £3.5 million above the baseline.
- Scenario 2 (Future Scenario with single additional open space) is estimated to improve health to a value of around £28 million above the baseline.
- Scenario 3 (Future Scenario with dispersed green space) is estimated to improve health to a value of £5.4 million.

3.2.6. Sensitivity analysis

We have assumed that the highest change in NDVI score would be 0.105–0.15 points, which is not enough to reach the HAUS threshold for reductions in premature mortality. If the NDVI could be raised by 0.24 points for the site, we estimate that premature mortality might be reduced by 3 cases per year–equivalent to around

TABLE 3 Net attributable health risks and benefits affected by green space: Baseline and scenarios 1–3 compared.

Environment change (intervention, asset or hazard)	Health outcome	Baseline cases[a]	S1 cases[b]	S2 cases[c]	S3 cases[d]
NDVI increase	Cancer (mouth and throat)	-	−0.23	−0.23	−0.23
NDVI increase	Respiratory (asthma)	-	-	8	8
NDVI increase	Weight gain	-	-	−41	−41
Proximity to green space	Activity	2,632	2,632	2,632	2,632
Proximity to green space	Mental health	125	125	125	125
Proximity to green space	Respiratory (asthma)	5	5	5	5
Proximity to large, attractive, open space	Activity	1,432	1,432	1,432	1,432
Quality of green space (pleasantness)	Life satisfaction	125	125	125	125
Quality of green space (safety)	Life satisfaction	125	125	125	125
Size of public open spaces	Diabetes	-	-	−10	-
Park improvements	Park use	-	171	171	171
Park use	Diabetes	−3	−3	−3	−3
Park use	Weight gain	−127	−139	−139	−139

[a]Baseline scenario: Population 9,241, all other conditions as present day.
[b]Scenario 1: Population 9,241, Policy Compliant.
[c]Scenario 2: Population 9,241, 1Ha additional green space in single unit.
[d]Scenario 3: Population 9,241, 1Ha additional green space dispersed across site.
Red highlighted text denotes deterioration in health. Green text indicates improvement in health.

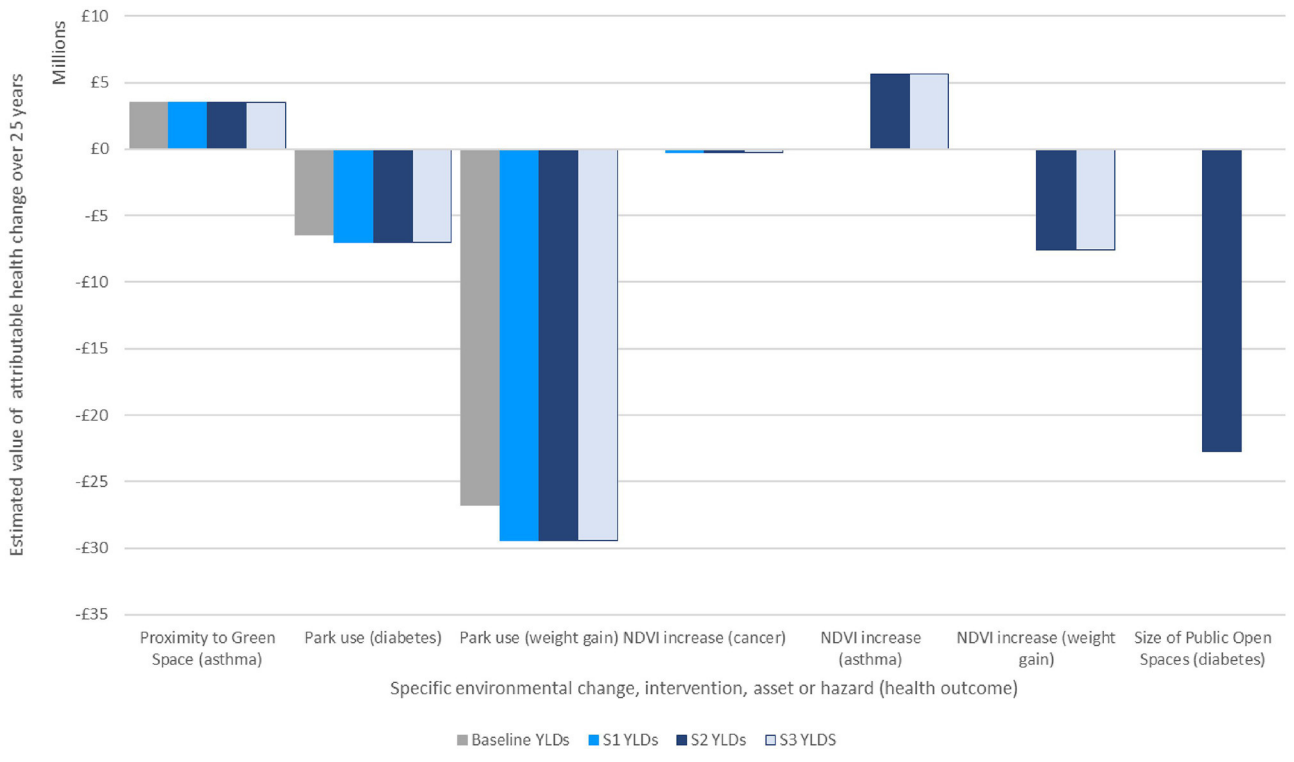

FIGURE 5
Estimate of economic valuation of attributable changes to morbidity over 25 years under each scenario.

680 premature life years over the lifetime of the project, at a value of around £41.5 million. However, a change in NDVI on this scale represents a dramatic change in the land use at Frome Gateway, including considerably more tree cover, and may not be achievable or appropriate for this urban site given other ambitions such as provision of housing and business space.

4. Discussion

There is growing demand for new approaches that will enable us to better account for the social and environmental external costs in urban development. A range of public- and private-sector stakeholders face a significant challenge in how they interpret and respond to evidence on a wide range of external costs and navigate the conflicts that these may generate with competing development objectives.

This study brings together in a model a substantial account of the current evidence base relating to the quantification and economic valuation of health impacts associated with the urban environment. Societal costs of illness for 78 health outcomes are incorporated into a model that represents 28 characteristics of the built environment. This approach offers an evidence-led way of comparing the effects of different urban form elements in terms of the potential magnitude of impact on health.

The interviewee responses suggest that both public and private sector representatives appear to be aware of many of the major health challenges posed by poor-quality urban environments. However, interviewees also recognized that health is not factored adequately into the urban planning process. There appeared to be considerable support for greater use of economic valuation to help improve decision-making. More specifically, interviewees suggested a very wide range of potential leverage points at which this type of valuation might be fed into the urban development system, at national and local level [see interview findings in Black et al. (12), Figure 1]. It was recognized that there is no "silver bullet" solution, with quantitative valuation of health impacts just one possible mechanism amongst the range of interventions needed.

With regards to the green infrastructure modeling, the HAUS model highlights the important role that existing parks and green spaces have for the health of local people, as well as the potential health benefits of improving the quality and quantity of these spaces. However, it importance will only be clear to potential users if outputs are presented in easy-to-digest forms and in ways meaningful to them. The exercise also serves to emphasize the need to define and measure changes in the urban environment–in this case potential changes to NDVI scores for the site under different scenarios, which may be resource-intensive for the model user.

The strength of the HAUS tool lies in its capacity to synthesize evidence from two strands of literature–on health impact pathways and economic valuation of health impacts–and combine it in such a way that specific project- or policy-based changes in the urban environment can be evaluated against health-related criteria. At the same time, there are inherent challenges in synthesizing evidence from across such a wide range of urban health and economic valuation literature which itself is derived from a diverse range of empirical contexts, using contrasting methodologies, assumptions and reporting protocols. There are also wide divergences in the quantity and quality of evidence available across the range of environmental characteristics. For example, children's health forms an important component of costs when relating to air quality, noise and food environment. However, there is very limited evidence on child health in the economic valuation literature. The resulting health impacts are therefore likely to be significantly undervalued.

We have not explored fully here the extensive uncertainties which are clearly present, therefore, within every aspect of the modeling process and this may be thought to reduce the value of the tool outputs. However, there are significant uncertainties inherent to any form of economic valuation of health outcomes. Such evidence is nonetheless widely used across decision and policy making systems and is especially prevalent in areas that require significant investment, such as in health and urban infrastructure, where it is currently used to justify expenditure (24, 43). Thus, uncertainties in valuation, however sizeable, do not necessarily negate its' usefulness; this depends on how that information is understood, used and valued. Future development of this tool and comparable endeavors that address the need for health to be given adequate weighting in urban development processes therefore require substantial attention being given to how such data can be most effectively communicated to the full range of stakeholder types. At the same time, further research is needed to help fill the more sizeable gaps identified in the literature so that, for example, there is a re-balancing of the weight of evidence toward areas other than air pollution in both health quantification and health valuation.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

EE: methodology, investigation, writing–original draft, and visualization. AH: conceptualization, methodology, supervision, and writing–review and editing. DB: conceptualization, writing–original draft, and writing–review and editing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

DB was employed by Daniel Black + Associates | db+a.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2023.1070200/full#supplementary-material

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Equity dimensions in initiatives promoting urban health and wellbeing in east and southern Africa

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Urbanisation in east and southern Africa (ESA) has brought opportunity and wealth together with multiple dimensions of deprivation. Less well documented in published literature on the ESA region are features of urban practice that promote health equity. This work thus aimed to explore features of urban initiatives aimed at improving health and wellbeing in ESA countries and their contribution to different dimensions of health equity. A thematic analysis was implemented on evidence gathered from 52 documents from online searches and 10 case studies from Harare, Kampala, Lusaka, and Nairobi. Most of the initiatives found focused on social determinants affecting low income communities, particularly water, sanitation, waste management, food security and working and environmental conditions, arising from longstanding urban inequalities and from recent climate and economic challenges. The interventions contributed to changes in social and material conditions and system outcomes. Fewer reported on health status, nutrition, and distributional outcomes. The interventions reported facing contextual, socio-political, institutional, and resource challenges. Various enablers contributed to positive outcomes and helped to address challenges. They included investments in leadership and collective organisation; bringing multiple forms of evidence to planning, including from participatory assessment; building co-design and collaboration across multiple sectors, actors and disciplines; and having credible brokers and processes to catalyse and sustain change. Various forms of mapping and participatory assessment exposed often undocumented shortfalls in conditions affecting health, raising attention to related rights and duties to promote recognitional equity. Investment in social participation, organisation and capacities across the initiatives showed participatory equity to be a consistent feature of promising practice, with both participatory and recognitional equity acting as levers for other dimensions of equity. There was less evidence of distributional, structural and intergenerational equity. However, a focus on low income communities, links made between social, economic and ecological benefit, and investment in women and young people and in urban biodiversity indicated a potential for gains in these areas. The paper discusses learning on local process and design features to strengthen to promote these different dimensions of equity, and issues to address beyond the local level to support such equity-oriented urban initiatives.

KEYWORDS

urban, equity, health, wellbeing, practice, east and southern Africa

Introduction

Rising urbanization, with urban populations projected to reach 62% of Africa's population by 2050, are observed by the World Health Organisation (WHO) and UN Habitat to constitute one of the most important global health issues of the 21st century (1). In east and Southern Africa (ESA) countries, urbanisation, while bringing rising and conspicuous wealth for some groups and increasing social connectedness, including through online media, also involves many dimensions of urban stress and deprivation.

Urban areas involve numerous social determinants that can contribute to inequalities in health. Many urban residents in ESA countries live in poor conditions, including substandard and overcrowded housing, water and sanitation systems, unhealthy cooking fuels and technologies, and exposure to health risks from solid waste, air and water pollution, traffic and hazardous working conditions (2–9). Despite being sites of innovation, enterprise and corporate wealth, many urban residents face employment and income insecurity; spend high shares of income on food, utilities and services; and experience rising levels of chronic disease from consumption of poor quality and ultra-processed foods, alcohol, tobacco and other harmful substances (2, 10–12). While services are generally available and geographically accessible, cost, quality and social barriers lead to inverse coverage, especially in meeting the health needs of poorest groups (2, 13–15). Conditions of social insecurity, crime and different forms of violence co-exist with isolation, exclusion and power imbalances within communities and in their interaction with authorities (2).

There is some indication that these determinants and inequalities may be intensifying, making equity a growing issue of concern in urban health (1, 2, 11, 12). Further, these multiple dimensions of social, economic and ecological deficit in urban and peri-urban areas are reported to have been further exacerbated by the COVID-19 pandemic and associated restrictions on movement (16, 17).

While there is documentation of such social determinants of urban inequality, what is less clear, and found to be less well documented in published literature from ESA countries, are features of urbanisation and urban practice that *promote* health equity and wellbeing (2). Various practices are documented to benefit health and wellbeing, with some reports also indicating benefit for low income, marginalised groups. They include urban agriculture (UA) for food security; regulation and taxation of harmful products such as ultra-processed foods, tobacco and alcohol; and health promotion in schools and communities. These approaches have been noted to be more effective when linked with measures that enhance leadership, literacy, social power and autonomy, and when they improve access to appropriate services in disadvantaged groups (2, 12). In the COVID 19 pandemic, initiatives in urban areas that built on prior capacities, processes and relations were able to pivot to a solidarity-driven pandemic response that responded to a range of social needs (18).

The limited documentation of features of equity-promoting practice can be a barrier to their wider application. While acknowledging the general conclusions reached in a global analysis of the drivers of and measures to promote equity in health and wellbeing (19), as a problem statement, the work presented in this paper was motivated by a need to more specifically document and understand the features of initiatives, practices and processes in urban areas of the ESA region that promote health and wellbeing, and from this, to understand those features that address different dimensions of equity. The work was implemented under the umbrella of the Regional Network for Equity in Health in East and Southern Africa (EQUINET) given its long term engagement on health equity, in dialogue with the Accelerating City Equity project of the International Society for Urban Health (ISUH).

Giving a focus to equity, a 'healthy city' has been defined as one that enables people to have equitable access to economic opportunities and services; that empowers people to achieve their potential and that nurtures natural environments (20). This resonates with EQUINET's focus on interventions that seek to allocate resources preferentially to those with the worst health status, backed by a redistribution of social and economic resources and measures to enhance the power and ability people and social groups have to claim rights and make choices over health inputs, and their capacity to use these choices for health and wellbeing (21). While there are various ways of conceptualising the drivers and forms of equity, See and Wilmsen in 2022 suggested a framework that may be used in analysing case studies of different areas of urban health practice (22). Noting a conceptual focus on distributive and procedural justice, they expanded the conceptualisation of equity to include the status, legitimacy and respect different groups have in presenting their interests, and the parity of opportunity they have to be included in decision making. They noted further the need to expose the underlying systemic processes that influence and create an uneven playing field for these other dimensions of equity, as also noted by Anderson as both driver and outcome of social relations that generate prejudice or impose disadvantage (22, 23). Drawing on these conceptualisations (22), and adding the dimension of the longer term impact on future generations and natural resources, we explored five different dimensions of equity, that were also proposed in the ISUH Accelerating City Equity project, and that resonated with the ESA regional understanding of equity. The five dimensions were thus: (i) *participatory or procedural equity*, in terms of groups' participation in, and their power and influence over decisions; (ii) *recognitional* equity, in terms of formal recognition of the conditions and rights of social groups; (iii) *distributional equity* in terms of the distribution of benefits, burdens and outcomes related to wellbeing; (iv) *structural equity* in terms of underlying policies, laws and norms; and (v) *intergenerational equity* in terms of the benefit for future generations.

Methods

Figure 1 summarises the steps followed in the multi-methods approach used.

Sources of evidence

A document review was implemented in May 2022 to capture evidence on initiatives promoting population health equity in urban/peri-urban areas in the 16 ESA countries covered by EQUINET

Abbreviations: CFHD, Civic Forum on Human Development; EQUINET, Regional Network for Equity in Health in East and Southern Africa; ESA, East and Southern Africa; KDI , Kounkuey Design Initiative; HEART, Health Equity Assessment and Response Tool; ISUH, International Society for Urban Health; PCH, Primary health care; SDI , Slum Dwellers International; UA, Urban Agriculture.

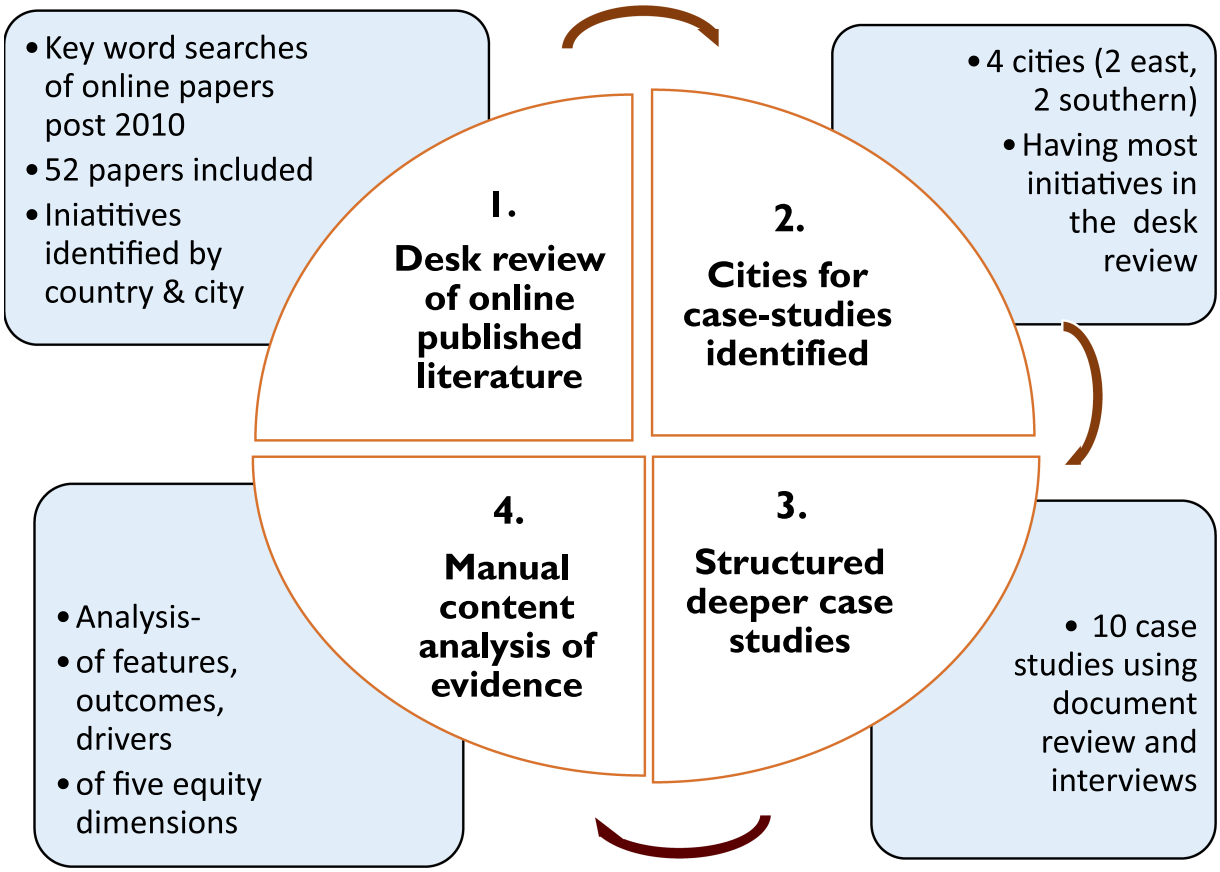

FIGURE 1
Steps followed in the methods.

(Angola, Botswana, DRC, Kenya, Lesotho, Madagascar, Malawi, Mozambique, Mauritius, Namibia, South Africa, Swaziland, Tanzania, Uganda, Zimbabwe, and Zambia). Rather than a systematic review, we used a focused narrative review, followed by structured case studies and content analysis as described below, given the largely qualitative, diverse, and non-biomedical nature of the evidence (24–26). As various methods reviews observe, a content-based focused review may be more usefully applied than a systematic review with such forms of evidence, where the effects are multivariate, the associations non-linear, and where there is need to draw insights both from common findings and from outliers (24–26).

The evidence was drawn from searches of English documents, post 2010, in online journals, Google Scholar, online libraries, and in institutional and international agency websites. For online libraries the search terms were 'Africa' or specific country names; 'urban health' or 'wellbeing' or 'equity'; and specific social determinants. Of the 196 papers found, 52 were included after review by RL and GM of abstracts and full papers, those in ESA countries relevant to practices promoting urban health and wellbeing included. A manual content analysis was used to extract evidence on features of sustained initiatives aimed at improved urban health and wellbeing, particularly for disadvantaged communities, noting the country and city location. Table 1 presents the distribution of the initiatives documented by country.

To explore the findings more deeply, four cities were identified from the document review for detailed case studies in Nairobi, Kenya; Kampala, Uganda; Lusaka, Zambia; and Harare, Zimbabwe. The number of cities was purposively decided on the basis of resource limitations, and to include two from east Africa and two from southern Africa. The selected cities were those that had a higher number of reports in the published literature of sustained initiatives with positive outcomes for disadvantaged communities, where available evidence indicated feasibility for deeper investigation. A local person involved with urban health in each of the four cities (DG, FG, CW, SC), whom we term a 'focal person' was involved in the final purposive selection and implementation of the case studies, and all four are co-authors of this paper.

Ten case studies, outlined in Table 2, were produced of specific, sustained urban initiatives across the four cities in June and July 2022, drawing evidence from review of a total of 122 published and grey literature documents relevant to the initiatives. Thirty four (34) interviews were implemented with diverse key informants with direct involvement in the initiatives in the four cities to review, validate and add to findings. The case studies collected evidence on the initiatives in terms of their contextual features, their aims, design and pathways for achieving intended changes, the way equity was addressed; the actors involved and actions implemented. The case studies reported on the time frames, resources and capacities applied, mechanisms and processes, spaces, measures and tools used and the monitoring and review applied, as well as the outcomes achieved. Evidence was included from the documents, key

TABLE 1 Areas of focus of initiatives found in the desk review (frequencies in brackets).

Country, city	# Papers	Broad area of focus of the initiative
Angola, Luanda (4)	4	Health services, community health workers; citizen generated SDG data for urban planning; low cost housing.
Botswana, Gaborone	1	Decentralised pandemic response, accessible Wi-Fi.
Eswatini, Manzini	1	Use of urban HEART tool to link evidence to planning
Kenya, Nairobi (11)	11	Health services (MCH; health provider training; contraceptive access); Disaggregated evidence for planning; community mapping; food waste management (2); Urban agriculture; right to food; food vendors; household energy; flood management.
Madagascar	1	Mahazoarivo Avarabohitra MCH health service
Malawi Lilongwe (2), Blantyre (1)	3	Health services (contraceptive access, NCD care); Waste management.
Mozambique, Maputo (8), Quelimane (1)	9	Food systems; urban agriculture; waste management; slum upgrading; energy; local architecture; harmful drug use; Citizen data for planning; online communications.
South Africa Ethekwini/Durban (3),Cape Town (1) Johannesburg (2)	6	Health services (family planning, surveillance); Food systems; urban agriculture; Low cost housing; clean environments; transport system.
Tanzania Arusha (1) Kinondoni District (1), not stated (2)	4	Urban PHC; Spatial planning; Greenhouse farming; food safety.
Uganda, Kampala (8), not stated (2)	10	Health needs; refugee wellbeing; community evidence; Food security; urban agriculture; household energy; flooding; waste management.
Zambia Lusaka (4), not stated (2)	6	PHC for NCDs; urban PHC; health system planning; health literacy. Food system; quality sanitation; community electoral voice
Zimbabwe Harare (5), Bulawayo (1) Other (3)	10	Health services (cancer screening; diabetes care; deworming); health committee; gender-sensitive planning. Food waste; solid waste management; community environments; sanitation; clean energy; slum upgrading

Loewenson et al. (27). Some papers included multiple countries (64 examples in 52 papers). No information found for Democratic Republic of Congo, Lesotho, Mauritius, Namibia, and Seychelles. SDG, Sustainable Development Goals; MCH, Maternal and Child Health; NCD, Non-Communicable Disease; PHC, Primary Health Care.

TABLE 2 Case studies by city and areas of work.

Country	# Case studies	Broad area of focus of the initiative
Harare, Zimbabwe	3	Sustainable access to safe clean water and sanitation services Urban agriculture in off-plot farming for income and food security Herbal and nutrition gardening for environmental management
Kampala, Uganda	3	Waste management to address flooding in slum communities Sustainable micro-gardens to address food insecurity Community-led water and sanitation response in informal settlements
Lusaka, Zambia	1	Participatory planning and action by communities and health workers in frontline health services.
Nairobi, Kenya	3	Kibera public space project for multiple services on underused sites Community-led mapping of food vendors in informal settlements Urban agriculture for income, food and ecological security

Chayikosa et al. (28), Goma and Mhlanga (29), Gotto and Mhlanga (30), Walyaro and Mhlanga (31), and Loewenson et al. (27).

informants and our own analysis of the learning on the drivers, enablers and barriers, equity dimensions addressed and insights that may be transferable to other urban settings. The full versions of the 10 case studies are separately provided (28–31), and a comprehensive report provides detailed information on the methods and empirical findings on the initiatives from both the document review and the case studies (27).

As the primary evidence was obtained from public domain secondary evidence from document review, and key informant interaction was implemented after consent for review and validation, this process did not require IRB review. However, we submitted the protocol through ISUH to the New York University IRB for review and received clearance to proceed. The key informant interviews for the case studies used a standard informed consent process, with consent obtained by the focal persons before interviewing key informants, and the key informants anonymised.

Analysis of the evidence

The evidence for a cross cutting analysis of the (i) common features, (ii) outcomes, (iii) drivers, and (iv) learning noted above was extracted through a manual content analysis within these four key thematic areas from the 10 case studies and 52 papers in the document review, identifying from the evidence further thematic clusters within each major theme.

As noted earlier, a particular focus is given to equity, both in the content analysis and in the discussion of the findings in this paper. The

manual thematic content analysis thus identified in the thematic areas above and more directly in the case study texts reference to the five different dimensions of equity explained in the introduction, *viz.*: (i) *participatory or procedural equity* (participation, power and influence in decisions); (ii) *recognitional* equity (formal recognition of the conditions and rights of social groups); (iii) *distributional equity* (in the distribution of benefits, burdens and wellbeing outcomes); (iv) *structural equity* (related to policies, laws and norms); and (v) *intergenerational equity* in terms of the benefit for future generations.

Limitations

The limited time and resources for the work in 2022 did not allow for deeper searches and snowballing in the desk review, or for wider field interviews, focus group discussions and observations for the case studies. We suggest that further research include these methods. Inclusion of only English language publications in the document review and of case studies from only four cities implies potential linguistic and geographical exclusions that would also need to be addressed in follow up work. Much local work may not be reported in published literature or may exclude negative findings (24–26). However, we based insights on triangulations of different sources, explicitly integrated insights brought by implementers, included negative outcomes in the case studies and subjected the findings to review and validation. The limitations may carry equity implications that should not be lost in the dialogue on and use of the findings. However, we consider the evidence gathered to be sufficient to support the features and insights presented in this paper, particularly those that were most commonly found across multiple case studies or cited sources and settings, while we also note unique experiences and innovations that may demand further research.

Results

Focus and outcomes of the initiatives

This section presents the common areas of focus and practices found in the document review, shown earlier in Table 1, and described in the 10 case studies, shown earlier in Table 2, together with the reported outcomes.

The tables indicate a spread of documented work across the region, mainly in the capital cities, usually focused on low income communities and informal settlements, and in some cases, in the peri-urban areas of capital cities. None of the initiatives made specific reference to a theory of change being developed and used to plan and support implementation, although most provided either qualitative outcomes with selected quantitative measures, or tracked targets for outcomes.

Areas of focus

As reflected in the two tables, most of the initiatives found take place outside the health system and are *focused on social determinants of health* affecting low income communities, particularly water, sanitation, waste management, energy, land, biodiversity, UA and food safety and security. This common focus suggests these social determinants to be potential priorities in the environments affecting wellbeing in low income communities in the ESA region. Where initiatives involved the health system, this was generally in relation to primary health care or primary care services, and the mechanisms for community engagement with these services.

While social determinants of health dominated, there were other areas of focus. Some initiatives had an explicit *social group focus*, such as work by refugee communities in Uganda to guide newly-arrived urban refugees and support them to overcome language and other barriers in accessing social, financial and other services (32). In this initiative, established refugee communities provide information, guidance and voluntary extension workers to help new arrivals access services in the city. They translate information into accessible languages and help to organise savings groups, given challenges refugees face in opening bank accounts, and advise on local enterprise opportunities (32). A further example of a social group focus was apparent in the community-led participatory mapping of informal food vendors in slum settlements in Nairobi, supported by *Muungano wa Wanavijiji*, the Kenyan federation of slum dwellers (31). This mapping raised the visibility of informal food vendor conditions and their contribution to food security in slums. It improved mutual understanding between vendors, residents and authorities, and brought vendor issues more centrally into the dialogue between communities and government on food systems (31, 33).

Some initiatives had *a system focus*. For example, the Lusaka case study focused on the primary health care (PHC) system in the city, and efforts by the local health authority to integrate community voice in service planning through joint local health worker and community committees; supported by community-driven participatory activities and community photography (photovoice) to bring community voice and priorities to these mechanisms; and health literacy outreach to link committee representatives to informed and active communities (29, 34, 35). Efforts to integrate community voice and build social accountability were found in other initiatives that had a systems focus. Participatory monitoring of waste collection implemented in 42 neighbourhoods of Maputo through a Monitoria Participativa Maputo (MOPA) communications platform sought to improve the city's waste management systems by enabling greater interaction between marginalised communities and local government (36). In this initiative, once a waste management problem is reported, one of two large waste collection companies and 56 micro-enterprises act to resolve it. The communications platform enables residents to directly notify the municipality of problems, track their resolution and get updates on when, and how, their issue has been addressed (36). In these and other initiatives engaging with systems, the focus was generally on the frontline, primary level services that are closest to communities, using participatory approaches to strengthen social voice and accountability and linking services to social determinants of wellbeing that are prioritised by the low-income communities served (27).

Beyond individual services, a minority of experiences involved integrated area-based approaches. A *spatial focus* in these initiatives enabled a more holistic lens, bringing together multiple services and forms of action, and addressing the multiple needs of low income informal residents. One case study in Nairobi exemplified this well. Kounkuey Design Initiative's Kibera public space project, initiated in 2016 and ongoing, addresses needs of local residents in Kibera, an informal settlement in Nairobi. It connects residents and local

expertise with technical resources to plan with communities and build services and infrastructures in underutlised public sites in Kibera. The activities in the case study integrated river remediation, flood protection; rainwater harvesting; drainage, sanitation and solar energy infrastructures; essential services; WiFi facilities; community buildings and spaces for small businesses and recreation (31, 37, 38). As a spatial initiative, it engaged local residents and diverse actors, resources and services within a defined area to address multiple dimensions of wellbeing, transforming ecosystems, and the built and social environment (31, 37, 38).

While the foci varied, common attention to disadvantaged, marginalised communities in most of the initiatives found implies an engagement with equity, discussed later. The determinants addressed were linked to deeper, often historical or current inequalities in urban development, with poor communities located in low-lying, often informal concentrated settlements affected by flooding and lacking infrastructure, or in areas encroached by land developers (27, 28, 30, 31). Rural–urban migration and rapid urbanisation have increased population density and pressure on infrastructures, exacerbating these conditions. While the experiences point to efforts to mitigate these challenges, discussed later, they also indicated a need for investment in infrastructures, services, land-use planning and legal standards to protect the interests of low income communities. Some of the initiatives strengthened the collective organisation of residents to engage the state on these duties, largely at local level, as a feature of participatory and recognitional equity, further discussed later (27).

Areas of change

The processes in the case studies point to the central role of social organisation and participation, both as drivers of change and as outcomes of the initiatives. In cases where interventions were initiated by non-state actors or local councils, social participation by affected groups played a key role in aligning designs to local realities and priorities, in gathering evidence on local conditions and assets, in organising resources such as in savings clubs, and in implementing and reviewing actions (12, 27, 33, 35, 36, 39–41). Deepening cycles of engagement, social confidence and power were noted as outcomes. However, these changes also took time. Many of the initiatives were sustained for more than a decade. Some benefitted from the links between local initiatives and wider social networks such as Slum Dwellers International (SDI) or EQUINET, or with local non-state actors or other cities, to draw on their experience, capacities and tools (27, 29, 31, 33, 39, 42, 43).

The initiatives found reported the achievement of a wide range of other outputs and outcomes. Some interventions achieved outcomes in more than one of the areas noted below, albeit not always formally monitored.

- There were *short and medium-term social changes reported*, such as new skills developed; shifts in attitudes, knowledge and participation by different social groups; a growth in membership of community networks and increased service uptake (18, 29–32, 44).
- There were *material changes visible to communities and authorities*, including a range of improvements in infrastructure, public spaces and services; together with introduction of appropriate technologies and services to address needs; improvements in household incomes; increased organisation of social funds; increased recycling activities and reduced waste dumping (28–31, 37, 43, 45–50).
- There were *longer-term, less easy to measure social, system and material outcomes*, such as increased community self-confidence; strengthened collaboration, solidarity, mutual understanding and improved trust between different social and institutional actors. These outcomes also included increased visibility of conditions affecting low income groups and their inclusion in evidence-based planning and local and wider political and social leadership recognition and support. In addition the findings in some settings showed improved appreciation and marketing of locally-produced fresh foods; reduced food wastage; improved soil quality and biodiversity; and increased pride in neighbourhoods (12, 28–31, 35, 36, 39, 45, 51–53).
- Some case studies identified *health and nutrition outcomes* drawing on routine service data. They reported reduced endemic communicable diseases, nutritional improvements and a decline in seasonal epidemic disease. There were also spill-over effects noted, with uptake of processes and technologies in wider communities, as well as in the social organisation and capacities generated by interventions being used more widely to address other urban challenges (28–30, 35, 54).

Enablers of and barriers to initiatives for urban health equity

The initiatives found in the document review and case studies gave evidence of a range of enablers and challenges. The more detailed inquiry on these in the 10 case studies is captured in Table 3. This section discusses the more common enablers, and challenges.

Enabling leadership and collective organization

The involvement of leaders, members and community-based organisations from affected communities was found to be a common enabler, in processes that listen to community priorities from the onset, and that strengthen collective organisation, capacities and dialogue during implementation. Leadership support from within the community, local authorities and from political and institutional leaders helped to champion initiatives, and sometimes acted as catalysts of or boosts for scale-up of innovation (29, 43, 45, 55) (See Table 3). For example, in Quelimane, Mozambique, the mayor of the city making it his priority to improve public services, infrastructure and food security opened space for various activities to improve solid waste management and UA. Having this leadership support stimulated new forms of collective organisation in urban farmer groups and waste recyclers, and strengthened cooperation between the local government, civil society and the private sector (43).

The commitment of particular individuals within communities played a role in catalysing and sustaining initiatives, especially when challenges arose. For example, in a herbal nutrition garden in Warren Park, a high density housing area of Harare, the persistent support for the initiative by the two founding innovators over more than a decade proved to be important to overcome challenges and to stimulate new ideas to overcome obstacles (28). However the same initiative also

TABLE 3 Enablers and barriers in the 10 case study initiatives (key measures shown in bold).

Initiative	Key enablers identified	Barriers/challenges and responses
Harare, Zimbabwe		
Enhancing sustainable access to safe clean water and gender sensitive sanitation services in Epworth	• Use of a **local participatory community-based targeting approach to identify beneficiaries** enabled inclusion of vulnerable households, community involvement and ownership. • **Working with the community leaders**, CBOs, councilors supported community involvement and sustained actions. • **Capacity building of community members** changed social attitudes towards water quality testing and good hygiene practices. • **Demonstrating effectiveness** of the intervention facilitated uptake. Central and local government support and participation enabled policy change.	• Authorization requirements by authorities at the provincial and district level delayed implementation, but essential as local government participation facilitated policy uptake. • Shortfall on resources to meet high demand for the technology. • Private sector inputs needed leverage from community or government, municipality, and external funders, with such local resources partially mobilised.
Urban Agriculture In Hatcliffe	• Unity, self-determination of community members and a shared purpose to address a key social need. • **Formation of Cheziya North Farmers Association** enabled activities, engagement with authorities and leadership, guidance and courage for members to sustain work, despite noted challenges. • Political leader perception of the activities as poverty reducing and enabling food security built support. • **Free technical support** from the Institute of Engineering staff improved yields. • **Fundraising for own projects** and for security for 3 months every year to protect fields.	• Contested land, lacking legal title undermined security of tenure. Urban land development reduced land for UA and displaced members. In response, the CNFA organised plot holder agreement to reduce farm sizes and found available adjacent land to accommodate all. • Theft of farm produce, overcome by employment of guards for 3 months during the crop season.
Warren Park 2, Herbal and Nutrition Garden	• Conducive terrain, climate, soil and water for UA. • Availability of land and **lease agreements**. • **Willing funding partners** to support the initiative. • Willingness of city council to sustain lease of land for UA despite non-payment of costs. • Residents' willingness to offer labour and commitment from the initiators to sustain the initiative during wider socio-political changes. • Perceived health benefit of local herbs.	• Unaffordable land lease fee led to membership dropout when external funding stopped but **founder commitment** and passion sustained the initiative to bring in new participants. • Sustainability affected by weak group cohesion, informal nature and external funder dependency.
Lusaka, Zambia		
Participatory Planning and Action by Communities and Frontline Health Workers in Lusaka	• **PRA tools**, community interest and district health management team, ministry of health and Minister support enabled and sustained **repeated and deepening cycles of action and learning** needed for effective community voice and confidence able to influence primary care and community health plans. • Election of **community members by the community for committees**, participatory dialogue and input on their **committee constitutions and roles** and **good information flow** between health services and communities built trust. • **Mechanisms for exchange across local areas**, like a national meeting of NHCs for sharing of experience and knowledge and to build collective analysis and voice across localities and districts. • **Documenting the work**, including online, and involvement in the EQUINET **regional network** widened knowledge, interest, and brought capacities, ideas and respect for the work. • The Minister's pronouncement for nationwide scale-up enabled wide roll-out of the program.	• **Legal mandates needed** for NHCs/HCCs post 2006, with guidelines for their functionality. • Initial challenges in getting health literacy prioritised at central MoH level, as curative programs often given higher priority. Countered by **ministry champions**, especially by the health minister's commitment to health literacy. • Collaborating partners sometimes had different targets and objectives for participating. • A perception of the photovoice as aimed at discrediting the local authority was overcome through community engagement with civic leaders on the issues and the options for and community contributions to resolving them.

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TABLE 3 (Continued)

Initiative	Key enablers identified	Barriers/challenges and responses
Kampala, Uganda		
Sustainable Waste management to address flooding in slum communities of Bwaise III parish	• **Co-design with affected communities** meant that members contributions and efforts were valued. • Intentional measures for community participation in the design and implementation enhanced buy-in and involvement by the different community members. • **Linking waste recycling to a household fuel.** • Local village and parish leaders created a supportive environment for implementation. • **Private company purchase of products** (briquettes, collected plastics) boosted local income. • Absence of affordable energy technologies enabled community adoption of briquettes.	• Challenges of space for drying products, connectivity and inadequate services in slums demanded creative measures and continuing engagement with the local authority. • Challenges of deficits in slum infrastructures are being addressed through advocacy with the local authority, mayor and councillors on priorities and on benefits for poverty reduction.
Sustainable micro-gardens to address food insecurity in Gayaza parish	• **Partnerships with wider stakeholders** including the church, private sector, NGOs and CBOs expanded reach to the most vulnerable, with partners meeting costs of UA inputs and training. • Community engagement through the local government, local development agencies and religious institutions, and **collaboration with research institutions enabled access to tested innovations** in UA, enhanced service quality, and boosted production. • Access to **a national innovation fund** enabled investment in the initial scale-up phase. • Timing during the COVID-19 pandemic meant people were receptive to learning new ways of UA to meet household food needs.	• Community discouraged by technology costs and risk of losses due to actions by authorities. Costs reduced by **using local materials**. • Absence of water for UA. Addressed through training on **water conservation, harvesting and storage techniques**. • Gender norms, weak male involvement, food preferences, household time demands. • Rural–urban migration creating land pressure leading to use of wetlands for UA, risking eviction.
Community-led water and sanitation in urban informal settlements	• Active and collectively organised engagement and participation of communities was instrumental for resources, self-determined implementation, as was support from and collaboration with local leaders. • Infrastructure development **providing local opportunities for jobs, incomes**, and building showed benefit for disadvantaged people.	• The COVID-19 pandemic restricted gatherings, halting activities for 4 months. • Central level politicians detached from local realities resorting to populism to excite local people used to discredit local initiatives.
Nairobi, Kenya		
Kounkuey Design Initiative's Kibera public space projects	• **Collaborative design** combining capacities, social assets, technical expertise from community leaders, residents and community based organizations. • **Productive vibrant and self-sustaining public spaces** as hubs that bring resources and community voice in policy and practice seen to improve livelihoods and service access. • Kounkuey **provision of technical skills, negotiating capacities and financial resources** to residents and local CBOs with joint decisions, cultural exchange, and shared responsibility in work. • **Kounkuey's capacities, credibility and reputation** for delivery and management and role in linking residents from informal settlements to official government and agency processes.	• Inefficient interventions by local and county governments and limited community access to basic services and infrastructures disrupt social networking and trust, added to by crime and unemployment in the community. • Limited data on slum communities weakens community engagement in policy processes. The **consultative and holistic design** of the initiative took these limitations and contexts into account in the design.
Community-led mapping of food vendors in Nairobi's informal settlements	• Commitment to the exercise by Muungano wa Wanavijiji and the residents of the 11 villages • The use of **participatory mapping methodologies** and expertise from the institutions vital for effective community and stakeholder engagement and for the success of the study. The use of focus group discussions, and a range of **PRA tools** gave the participants platforms and opportunities to share concerns, experiences and recommendations. • Learning **mapping and PRA skills** has helped communities organize collectively and negotiate with other stakeholders, partners and local government for improved services and livelihoods.	Challenges faced by slum dwellers and urban poor people such as exclusion from policy development on key areas where they face deficits or threats, e.g., on slum upgrading, access to services for water, sanitation, transport and energy and electricity and crime and unemployment. The mapping initiative itself generated evidence on these deficits for more formal engagement with duty bearers.

(Continued)

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TABLE 3 (Continued)

Initiative	Key enablers identified	Barriers/challenges and responses
Urban agriculture in Nairobi County	• County government interventions supporting resident actions, backed by a **clear legal mandate, enabled inter-sectoral capacity building, technical assistance** and **platforms** for further engagement, learning, sharing, action and advocacy on UA, as did partnership with international, national and local organizations, community leaders and CBOs, civil society, academia, and private sector. • **Giving focus to equity in decisions** enabled reach to informal settlements.	• Poor essential service delivery in informal settlements and cumbersome county operations a barrier to partnerships. Addressed in part by capacity inputs and platform in the design, • COVID-19 impacts and climate and weather changes affect gains made in food systems, addressed in part by improving UA practices and food systems.

Chayikosa et al. (28), Goma and Mhlanga (29), Gotto and Mhlanga (30), Walyaro and Mhlanga (31), and Loewenson et al. (27). CBO, community based organisation; HCC, health centre committee; NHC, neighbourhood health committee; PRA, Participatory reflection and action; WASH, Water, sanitation and hygiene.

indicated that individual leadership maybe insufficient when those involved lack a shared vision and buy-in and are weakly organized collectively, making initiatives vulnerable to disruption (28).

Many of the other experiences thus highlighted the role of investing in social organisation, networking and local capacities for communities to organise evidence, pursue rights claims and engage authorities; as well to enable shared decision-making in response to challenges; and foster solidarity across different social groups in the community (27, 28, 43, 46, 56, 57). In Harare, for example, low-income informal residents in Hatcliffe suburb facing challenges to food and income security organised collectively with support from the Civic Forum on Human Development (CFHD), Zimbabwe Homeless People's Federation, a community organization, and the International Organization on Migration to identify urban land for collective engagement in off-plot urban agriculture. The residents, coming from a marginalized and disadvantaged community in the city, formed and formally established the 'Cheziya North Farmers Association' to build trust and transparency in land allocation to residents for UA. The association provided a sustainable mechanism to support their collective power in facing the significant power imbalances when engaging with local authorities, political actors and land developers. The association was able to leverage collective funding, action and wider institutional contributions for other inputs prioritised by the households involved, including solar powered boreholes, electricity connections and piped water (28).

The initiatives involved processes that explicitly support such collective organisation and agency in communities, including various forms of co-design, literacy, community skills building, and free technical support. The participatory methods and tools used in several initiatives provided collective ways of profiling local lived experience, cultures and knowledge, particularly when embedded in iterative stages of action and learning (58), as exemplified in the strengthened social participation in frontline health services in Lusaka (29, 34). Community confidence was further enabled when processes engaged with communities in their own settings and daily activities, to listen to their views, to use their inputs to adjust design and implementation, and to give feedback on plans (29, 30, 36, 43, 53).

These various participatory and collective processes commonly took place in wider conditions of social and economic insecurity. They are thus not a simple or singular remedy for precariousness. For example, initiatives that relied on community volunteers without making links to improvements in their incomes sometimes overburdened already poor people. This was noted to call for upfront discussion of fairness in the different roles, demands and resources needed for change (59, 60). Local laws and actions by authorities sometimes created obstacles and disempowered local actors and communities (28, 30, 32, 43). While the social organisation discussed earlier helped to address such challenges, social measures do not substitute state duties. As discussed later, deeply rooted problems also call for action from higher level authorities.

Bringing multiple forms of evidence to the table

With the gap in disaggregated data in formal systems noted earlier, surveys and other forms of community-led mapping, community surveys, focus group discussions, walk through surveys,

photovoice and participatory ways of generating of evidence helped to expose often hidden conditions, strengthening local voice on priorities, and contributing evidence to the co-design, monitoring and review of initiatives (27, 33, 40, 55, 61), as also shown in Table 3. In Matsapha, in Manzini, Eswatini, for example, community and institutional actors in the town used the WHO Urban Health Equity Assessment and Response (Urban HEART) tool to expose gaps in the support provided for wellbeing between urban residents and the large low-income workforce living in the peri-urban fringe areas of the town. The findings on major equity gaps in water, sanitation and waste management; housing, living and neighbourhood conditions; health systems; and access to primary health care were brought to inclusive dialogue to prioritise, plan and implement interventions (55).

Many initiatives integrated 'listening' and consultation with affected communities to understand their experience, needs and perceived priorities. This was described, for example, in the consultative processes held by KDI in Kibera (31), or by TAU Uganda and ACTogether in informal settlements in Kampala (30, 62, 63) (See Table 3).

This appeared to be even more powerful when communities were directly involved in gathering, analysing, reporting and using the evidence. In numerous examples, the use of participatory methods enabled lived experience, evidence and analysis to be integrated, using collective processes involving affected communities, and through this building their self-confidence and evidence-base to claim recognition of their priorities (27, 33, 34, 56). Hence, for example, SDI and Muungano wa Wanavijiji, the local informal dweller association in Nairobi, together with informal vendors used their own mapping to profile and negotiate improvements with authorities in their conditions (31, 33), as did community representatives in health centre committees in Lusaka, using participatory research and photovoice (34, 64). These participatory forms of assessment and analysis not only enhanced recognitional equity, but were also reported to strengthen voice in claims over rights and social accountability. This was found, for example in the use by SDI in informal settlements of a 'right to the city' lens to map rights violations and duty bearer deficits (65) as well as in forms of appreciative mapping to identify local options and assets that contribute to addressing rights deficits (32, 66). In Maputo's Monitoria Participativa Maputo (MOPA) example described earlier, the integration of participatory methods within a smartphone based platform helped marginalized communities to link evidence to response from authorities, strengthening social accountability over waste collection in the city (36).

The use of participatory tools in generating evidence to inform interventions signals a respect for community knowledge and experience (58). However, there was less indication of how such evidence interfaced with routine data, or of the weight and value assigned to these different forms of evidence in design of interventions. There was some note of joint monitoring by communities and authorities, such as in assessing water quality in Epworth, bringing shared evidence into planning (28).

Co-design and collaboration across multiple actors, sectors, skills and disciplines

The findings indicate that contextual conditions sometimes triggered initiatives, such as in the demand for affordable energy in Kampala, flood management in Nairobi and Kampala, and for UA when the COVID-19 pandemic disrupted food sources in all settings (27).

Initiatives needed to integrate specific measures for communities in precarious situations to have confidence in options. Such measures included initial demonstration by 'early adopters,' or bolstering uptake with skills training and resources. In Epworth, a peri-urban, high density low income settlement in Harare metropolitan area, efforts to address deficits in clean water and sanitation in this water-scarce area called for new, water-conserving sanitation technology. A water-conserving toilet innovation was introduced first in 30 pilot households to demonstrate its potential for the wider community. As support for the initiative grew, a 'lending group' was formed to fund a locally-driven scale-up (28). Similarly in Gayaza, a peri-urban area of Kampala, the potential for urban micro-gardening was demonstrated by Agriculture for Health and Wealth, a local non-state actor, through a model demonstration site. The site mimicked the small spaces available for low income urban homes, and local leaders and community members were brought to see the options for micro-gardening, with discussion of their situations used to inform outreach (30).

The mix of determinants affecting low income communities called for diverse actions to produce change, even for more focused issues. Measures to produce social improvements were linked in some initiatives to measures for local employment and incomes, supported by affordable technology and training and organisation of new roles; and by various forms of funding to catalyse these opportunities (Table 3) (2, 27, 37, 38, 47). For example in the Gayaza initiative described above, in addition to building capacities for urban micro-gardening in households and schools, the initiative established a shop selling affordable farm inputs. The income from sales and marketing of surplus food from micro-gardens in neighbouring communities helped to resource the activities and improve household income (30). In the Epworth initiative, local youth were trained as pump minders to maintain new water systems, generating income and employment (28). In Bwaise Kampala, an initiative on waste management to address flooding recycled the collected waste to produce briquettes that were then sold locally for household energy use, making links were made between flooding, waste management, waste recycling, energy use, private markets and urban infrastructures (30, 39).

These diverse areas of action called for co-design and collaboration across multiple sectors, actors and disciplines. Area-based approaches, such as in the Kibera public space project described earlier offered space for this, as did having clear and agreed roles and procedures, as described in the joint health service community committees in Lusaka (44) or the management and maintenance of water and sanitation systems in Epworth, Harare (28).

As shown in Table 3, the convening of multi-stakeholder platforms provided a space for dialogue and helped to build shared priorities, as well as support for and the legitimacy of initiatives across the different actors involved, including those contributing technical, technology, financial and enterprise inputs (27, 56). Convening by or with the local authority brought the legal mandate and authority of local government to discussions across sectors, actors and with service providers, as described earlier in Quelimane and Lusaka, or in Nairobi county council's convening of multiple actors around plans for urban food security (29, 31, 43, 50, 56, 57).

Such multi-actor processes are not always found within local authority cultures. Some initiatives used iterative steps, some moving

from informal to formal platforms, demonstrating improvements, to progress what was often gradual institutional change towards a more inclusive governance culture in the city to 'open up' to local communities, and to adopt new sources of evidence, measures and approaches (29, 30, 39, 40, 55, 56).

Co-design, co-production and joint review was itself supported by regular information flow between actors, including through representation on committees and dialogue forums, health literacy outreach and exchange visits (29–31). These forms of outreach helped to keep dialogue and planning connected with wider communities. The findings suggest that collaboration was also fostered by joint participation in training activities, by involvement of expertise from different disciplines, and by funding streams that supported cross sectoral innovation (See Table 3) (27, 39, 43).

Catalysing and sustaining change

The processes, measures and tools that enable these initiatives often appeared to be catalysed by or to involve values-driven and committed institutions and technical/professional actors. These actors act as credible partners in consulting, information sharing, brokering links and negotiating between communities, authorities, and other agencies (27; Table 3). Hence, for example, the workers within the local health authority in Lusaka played a catalytic and convening role in strengthening community voice in planning and budgeting for frontline health systems in Lusaka (29). The Nairobi county council provided a multi-actor platform to gather and enable dialogue and review across the different organisations and actors leading change around the laws, technologies, systems, production, processing and marketing of interventions for food security in urban Nairobi (31). In some initiatives these catalysts leveraged relevant technologies, resources and inputs to enable options, and demonstrated the feasibility of changes in pilot and demonstration sites (27, 36, 37, 47).

While these key catalysts were generally local, exchange visits across cities and in regional networks gave confidence and ideas to local actors. This was found, for example, in the slum dweller association exchanges between Ghana-Nairobi that triggered the vendor mapping in Nairobi (31); in the EQUINET regional links that brought ideas and experience for the participatory, health literacy and photovoice work in Lusaka (29); or in the co-operation between Milan and Quelimani that shared skills and technologies for urban food security (43).

Various challenges were faced in initiating and sustaining these changes, exemplified in Table 3 for the case studies. Rapid urbanisation, private developments, service declines or rising costs generated pressures and tensions over funds, land and other resources, and with service deficits generated insecurity and frustrations. It was not always easy to leverage private investment and private sector participation (41). Political and social contestation, conflict over land, scarce and unpredictable resource flows, legal and bureaucratic constraints and infrastructure and service deficits presented as challenges in diverse initiatives (27, 67). External project funding often helped to fund innovation, but its unpredictable nature and short term targets were also found to constrain the processes or time needed to build more grounded change (27, 28).

While the enabling features described earlier helped to tackle such challenges, these challenges also demanded strategic and creative responses to sustain initiatives. Being more locally grounded, participatory, and having links to services, systems and local sources of power helped to sustain and even deepen processes, despite challenging conditions and periods. So too did the engagement of higher-level policy actors, or the horizontal spread of practice in iterative steps, providing opportunities to document and profile the changes achieved, drawing in local, national and regional and international support and exchanges (2, 27, 29, 31, 42, 46, 57). The links made between social measures and economic and ecological benefits in disadvantaged communities described earlier also helped to strengthen sustainability. The range of enablers described in the paper appeared to intersect, with multiple levers used, implying that no single enabler can be read as a 'magic bullet.' Within contexts of significant and deep inequality, however, the challenges to sustainability cannot be under-estimated.

Discussion

This section draws on the findings from the document review and case studies to explore their implications for urban health equity. Table 4 summarises the findings in the results within the analytic framework of the five key dimensions of equity.

An analysis in 2018 of cross-country databases covering ESA countries drawing data from global observatories, UN databases and reported demographic and health surveys found limited disaggregation of evidence within urban areas or by social group (2). Disaggregated evidence that can help to understand distributional outcomes within urban areas is more likely to come from sentinel sites and surveys, and from participatory, qualitative assessments involving those directly affected. However these approaches are more *ad hoc* and limited in coverage, do not use comparable methods or sampling frames across countries, and there was limited evidence found in the 2018 analysis of systematic use of these latter forms of evidence in urban planning (2). This makes it difficult to have a systematic understanding from measured data of equity outcomes within urban areas across ESA countries.

As noted in the methods, the understanding of equity from global analyses, in EQUINET, and in the Accelerating City Equity project covered wider dimensions than the quantitative assessment of distributional health outcomes. The framework applied in analysing the extent to which equity was addressed in the different initiatives, defined and described in the methods, thus included dimensions of recognitional, participatory, distributional, structural and intergenerational equity. The findings discussed in the last section point to areas of progress and deficit in these different dimensions of equity in urban health and wellbeing, as also summarised in Table 4.

Participatory and recognitional equity as both drivers and outcomes

The common focus in the initiatives on conditions affecting low income and marginalised communities linked recognitional equity to various means of exposing often undocumented shortfalls in living, working and wider conditions affecting health and wellbeing, and using the evidence to raise attention to the implications for rights, duties and areas for change to improve health.

TABLE 4 Key dimensions of equity in the ESA initiatives.

Initiative	Recognitional equity	Participatory equity	Distributional equity	Structural equity	Intergenerational equity
Harare, Zimbabwe					
Enhancing sustainable access to safe clean water and gender sensitive sanitation services in Epworth	Elevated recognition of deficits in meeting rights to safe water and sanitation. Involved rights to information, participation in planning and management	Established capacities and mechanisms to strengthen inclusion in assessment, planning. Included participatory methods building social power and voice.	Benefit in a low income community with weak links to formal planning systems. Bias towards low income, female and child headed households and people with disabilities.	Linked technology innovation to local health and economic benefit. Policy recognition led to change in WASH approach	Technology innovation conserving water use in area of water stress suggests benefit for future generations.
Urban Agriculture In Hatcliffe	Rights claimed to occupy or lease land, and to UA for household food and incomes.	Establishment of an association to resist powerful political confrontation and address court challenge on land.	Land distribution to low income, food insecure members for UA, but falling land sizes as land taken for urban development.	Land and UA claims raised policy and legal land, food security and welfare system issues.	Assertion of low income land and UA rights relevant to longer term urban development and benefit for future generations.
Warren Park Two, Herbal and Nutrition Garden	Right claimed to land and UA	Shifted from individual towards collective leader-ship, albeit with still weak collec-tive organisation	Benefit to youth, women and elderly in a low-income community	Formal recognition of UA in a five-year renew-able lease, but with high fees.	Youth employment and protection of local indigenous foods sustaining culture.
Lusaka, Zambia					
Participatory planning and action by communities and frontline health workers	Rights recognised to healthy living and social conditions	Right of communities to participate in health service planning and budgeting	Increased focus on social determinants of health prioritised by low income communities	Policy for joint service planning by health workers and community	Reforms to comprehensive PHC that address determinants supports longer term benefit.
Kampala, Uganda					
Sustainable waste management to address flooding in Bwaise III slum communities	Right addressed to healthy, waste and flooding free community environments	Right to design, organise waste management and state duties to provide services. Female leadership	Mapping prioritised the worst affected.	Waste recycling inked to local technology, economy and incomes	Reuse and recycling promoted environmentally sustainable measures.
Sustainable micro-gardens to address food insecurity in Gayaza parish	Right to food and to produce food recognised.	Supported social agency through capacity building, but not in decision-making.	Technology, and support for land constrained low income house-holds	Policy recognition of micro-gardens for UA in high density areas.	Social enterprise as a sustainable model linking social benefit to economic activity.
Community-led water and sanitation response in urban informal settlements	Rights addressed to water and sanitation in slum communities	Organised community-driven structures and measures for information, planning, services for slum-dwellers.	Collectively mobilised local resources to lever wider investments. Equity criteria for inclusion and roles for disadvantaged groups in slums.	A community contracting model used now integrated in government guidelines.	Measures for inclusion of children and youth in technology outreach suggests long term benefits.
Nairobi, Kenya					
Kounkuey Design Initiative's Kibera public space projects	Rights addressed to healthy public spaces, environments, infrastructure, sanitation, community and small enterprise facilities.	Community networks participated in collaborative project design and planning.	Covered low income informal settlements, especially women and youth. Used evidence, tested ideas to support distributional outcomes. KDI resources matched community labour and in kind inputs.	Led to a new integrated upgrading programme and a Special Planning Area. MoU with Nairobi County to address flood associated risks	Connecting environmental measures to economic opportunities and social capacities, especially in youth, presented a long term model, including to prepare for weather events.

(Continued)

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TABLE 4 (Continued)

Initiative	Recognitional equity	Participatory equity	Distributional equity	Structural equity	Intergenerational equity
Community-led mapping of food vendors in Nairobi's informal settlements	Deficits in food security identified, while raising recognition of informal food vendor contributions.	Community-and food vendor led mapping and discussion of findings	The assessment gave voice and evidence to food vendors in engaging on discrimination against them.	Evidence generated used in negotiations by vendors and organisations	Better conditions for informal vendors may be a key determinant of more sustainable urban development.
Urban agriculture in Nairobi County	Rights addressed to food, land and inputs for UA, including as a basis for improved incomes	Local authority led, but involved key Urban stakeholders and community organisations	All residents, especially slum dwellers benefitted, but the distributional impact was unclear.	Strategies identified to implement to UA laws and review land ownership title deeds.	Co-operation between local authorities and stakeholders on sustainable UA and urban ecologies.

Chayikosa et al. (28), Goma and Mhlanga (29), Gotto and Mhlanga (30), Walyaro and Mhlanga (31), and Loewenson et al. (27). UA, urban agriculture; WASH, Water, sanitation and hygiene; MoU, Memorandum of understanding; KDI, Kounkuey Design Initiative.

This attention to profiling conditions made various forms of mapping, surveying and assessment a key step across many initiatives, to identify current conditions, to profile prioritised areas of need and those at higher risk, as well as to reveal the social, institutional and other local assets for change. The Manzini, Swaziland use of the urban HEART tool described earlier exemplified this (55). Such assessments have been used to inform the priorities for and design of interventions, to generate socio-political attention to the need for change, and to assess change (27, 40, 61).

Recognitional equity appears to be even more deeply fostered when affected communities themselves are involved in various forms of participatory assessment, as described earlier in the range of examples of work with slum dwellers, informal vendors, low income residents, urban farmers and others. They use participatory surveys and mapping (31, 33), participatory action research and photovoice (34, 64), or smartphone based applications (36). Involving local people in the generation and analysis of evidence not only informed initiatives, but built social confidence for those affected to claim recognition of their priorities, particularly when linked to rights based approaches, as described earlier in claims on rights to food, to the city, or to local authority accountability for services (36, 53, 65). Listening to communities from the onset, consulting those affected during the processes, and more deeply organising evidence and analysis within and from affected groups brought new evidence to planning processes and recognition of the local assets that contribute to addressing them (27, 32). It thus made the design of initiatives more relevant to the local situations, and built ownership of these initiatives amongst those affected (27).

Beyond participation in bringing evidence to stimulate, frame or track initiatives, the findings also point to the critical role of investments in wider forms of social participation in many of the initiatives. As earlier described, the processes establish, and strengthen inclusion in and capacities of mechanisms and dialogue forums. They also provide a range of training and capacity building activities to enable intervention by communities in these forums (27, 53, 57).

Many of the initiatives described in the findings strengthened associational networking, organisation and collective leadership, to engage within the processes, in the mechanisms for dialogue, and to support the collective social power for those in precarious conditions to negotiate claims, face challenges and manage contestation (27), such as detailed earlier in the example of the Cheziya North Farmers Association in Harare (28). Local political and institutional champions helped to support these forms of collective capacity building, organisation and voice in the community, as described in Lusaka and Quelimane (29, 43).

The common investment in various forms of social participation, organisation and capacities across the initiatives highlight performance on participatory equity as a relatively consistent and potentially central feature of promising practice in urban wellbeing. A growth in social organisation, power, self-confidence and engagement with and influence over decisions in the initiatives points to gains in participatory equity. Such gains were not simply outcomes in their own right, but also appeared to be important levers for other dimensions of equity.

Distributional equity implicit in the focus and design

In a context of limited disaggregated routine data in cities, the various areas of improvement noted in the findings suggest gains in

distributional equity. Most initiatives poorly captured the relative gains for different social groups through monitoring or routine data. Some initiatives included research to formally assess differential health outcomes related to specific urban services, albeit without attributing to specific features of interventions (4, 13, 54, 66). Embedding more systematic and distributional performance and outcome monitoring in initiatives for urban wellbeing and improving the within-area disaggregation of routine data systems would appear to be a significant area for further development.

The location of a majority of the initiatives in disadvantaged communities, such as low income and informal residents, precarious workers, and those with least social power, and the explicit intention of interventions to address various drivers of disadvantage indicated an intention to support distributional equity.

Many initiatives described in the findings thus addressed distributional equity by improving wellbeing for specific marginalised communities. For example, in the context of Uganda's policy of integrating refugees into existing urban communities, the initiative linking newly arrived refuges with existing networks of refugee communities described earlier helped to address the various dimensions of the disadvantage they face (32).

Where initiatives and services covered the entire population of the area and intended to benefit all in the community, specific measures were included to facilitate benefit for specific groups, such as women, youth, elderly people, or people living with disabilities (29, 31, 50, 54). The various examples described earlier, including those detailed in Epworth, Lusaka, Gayaza and Bwaise Kampala (28–30) indicate that this involved outreach to, literacy and training in and involvement of leadership from disadvantaged social groups and areas; demonstration sites and uptake by 'early adopters' to boost confidence in options for those in precarious conditions, and bolstering their uptake with skills training and resources. Linking social improvements to measures for local employment and incomes, supported by affordable technology and various forms of funding also helped to catalyse and sustain involvement and uptake by those in insecure economic conditions, such as women farmers in urban slums, and unemployed youth.

Making such links between social, ecological and economic benefits appeared to be important for distributional equity. As noted later, this feature also has pertinence in addressing structural equity. While barriers such as land development, resource deficits, conflict with authorities and legal challenges acted to weaken distributional equity, they were countered by measures that linked social interventions to local organisation, and to opportunities for employment and incomes (2, 27, 39, 45, 49).

Investing in youth and sustainable models for intergenerational equity

Intergenerational equity was not noted as a specific goal in the initiatives found. It was however integrated through investments that sought to protect urban biodiversity and environments; or to apply sustainable approaches for urban agriculture, waste management and recycling (27, 53, 54). A number of initiatives included investments in youth capacities and roles, such as the role of youth pump-minders in Epworth, Harare. Such investments could enhance intergenerational equity. Some initiatives have more explicitly engaged young people on their futures. In participatory dialogues, different groups of young people in Harare and Lusaka identified their perceived priorities for health today, and those that they saw as becoming more critical in the coming decades, engaging on these with the local authority (2). Also in Lusaka, a 'food change lab' that brought youth together with other food system stakeholders in the city, under the banner of 'Youth for Sustainable Food Zambia' discussed how to meet current and future needs for healthy food in the city, particularly for low-income consumers (53). These are isolated examples. There appears to be scope for more explicit integration in urban initiatives of applying a 'future lens' to assess how far approaches address projected risks in the future, and to integrate the voice and role of young people in this and in decisions that affect them.

Assets for and challenges in addressing structural equity

The initiatives outlined in the findings raise policy or legal issues relevant to structural equity, There was, however, limited report of policy change. One example of such policy change was in ACTogether's work with the National Slum Dwellers Federation of Uganda and partners to improve water and sanitation in Kampala slums, where a community contracting model was developed for informal residents to contract builders from amongst marginalised members. This contributed to a new policy framework by Uganda's Ministry of Lands Housing and Urban Development to guide community contracting (30). While the findings indicate examples of authorities waiving land leases or enabling more inclusive dialogue, there are fewer examples of such formal changes in national procedures.

Local initiatives in precarious communities in ESA face challenges in addressing structural equity, given longstanding insecurity and barriers to self-determined action, organisation and initiative, wider top-down hierarchies of power in planning and regulatory systems and their enforcement, and unpredictable financing and socio-political volatility that disrupts the time needed for improvement cycles and achievements to build deeper changes (27, 28, 48, 50). As Anderson notes, systemic or structural inequities drive or reinforce social relations that exclude and disadvantage some population groups, entrench stigmatising representations of these groups in public discourse and perpetuate their exclusion from state and private forums where decisions are made. Confronting such inequities is thus argued to be critical for democratic society (23).

The findings highlight how some processes bring together several sources of power and resources around shared goals to address these challenges. These processes converge leadership or champions from within communities, civil society, technical agencies and local governments around shared goals and actions, and involve institutions able to engage and promote the benefits and wider application of the work with higher levels of power and authority (27).

Some initiatives showed evidence of new approaches in urban economies and services through the local development and introduction of appropriate and accessible technologies. This was noted for example in actions described in the findings on water and sanitation systems, on waste management, on food systems, communication applications and equipment for health services (27, 45, 48, 63, 68).

Many of these technological and material approaches were self-initiated within communities, as a direct response to local conditions,

or developed and introduced by local institutions working with communities. The evidence highlights the potential for community and local innovation. It also suggests that gains in equity in technology innovations maybe more sustained where there is local control over the design and production of technology, to ensure its relevance and accessibility, and to link technologies to local employment and incomes for disadvantaged groups, with support from wider skills processes. With local levels often innovating but having limited authority and scope to address many of these policy-related issues, it is argued that technology as a support for equity cannot be left as a micro-issue, and needs to be linked to wider urban planning systems and services and to national resources for innovation.

Learning and insights on improving urban health equity

The findings clearly indicate that equity-oriented action and change in urban areas is both necessary and possible. While not always explicitly addressed or monitored, the initiatives for urban health and wellbeing found in the document review and case studies point to a range of practices underway, and to insights that may be more widely transferable. These relate to their processes, their design, and to features that lie beyond the initiatives themselves.

Processes for equity-oriented change in urban wellbeing

Processes that explicitly integrate measures and tools for participatory equity and recognitional equity are pivotal, as they appear to be entry points for gains in other dimensions of equity. The power imbalances in current urban contexts call for rights-based and social accountability approaches that link conditions to rights and duties; for iterative stages that deepen and widen trust across actors; and for investment in social organisation, capacities and power. The measures for this include listening to and consulting affected communities from the onset and in their own settings, and exposing their lived experience. The latter can be done through various forms of mapping, including participatory assessments, where affected groups are themselves capacitated to gather, analyse and identify evidence and priorities.

Promoting participatory equity implies inclusion in design on investment in the skills and capacities of key social groups, and use of processes that explicitly strengthen community networks, collective organisation, 'active citizenship' and community leadership, with particular attention to often excluded and marginalised groups, such as women, young people, people with disabilities, informal workers and residents of informal settlements. Whether in informal or formal associations, or membership-driven social networks, or in service, sector or local authority committees, having elected and mandated community representatives, clear, agreed procedures and active feedback and health literacy outreach to local residents can avoid communities being silenced by procedures, and avoid representatives becoming delinked from their communities.

Monitoring, documenting and reporting the distributional changes from these measures for participatory and recognitional equity, including changes in social power and confidence, are important for strategic review of processes, and to share learning, including across different cities and countries. This not yet well integrated in initiatives. It is important for facilitating recognition of the key role of investment in these dimensions of equity for leveraging other distributional and structural equity outcomes.

Designing initiatives for equity-oriented change in urban wellbeing

The findings indicate that initiatives for urban wellbeing operate in complex contexts, often confronting longstanding deficits and inequalities exacerbated by recent trends, including climate, pandemic and other shocks. Such complex problems are not solved in siloes. Improving equity calls for measures that stimulate cross sectoral, multi-stakeholder and holistic responses to these multi-dimensional drivers of inequality and deprivation, in sustained approaches and integrating strategic review. This implies pivoting from a focus on a single problem to acting on the multiple determinants of that problem, to bring together the different interventions and actors who play a role in pathways for change on the problem, and to link social, economic and ecosystem benefits from action. The findings suggest that area-based approaches offer potential for such co-design and co-located approaches, but still merit wider further application in urban practice.

In more issue, system and social group focused work, various features enable holistic approaches. They include having credible 'brokers' that link and leverage the contributions of the different types of actors, skills and resources and local assets; explicitly integrating processes that stimulate and build relationships, trust, partnership and collaboration in the design of initiatives; including joint training activities; and involving research, development, testing and demonstration and introduction of appropriate technologies.

Ensuring an equity lens means integrating the measures for participatory and recognitional equity previously noted, but also linking activities that bring social benefit to economic opportunity for low income communities, including through purchasing and community contracting models that formalise community roles; and embedding capacity building, skills transfer and economic opportunities for local community members, especially women and young people.

Here too there is need for more widespread regular monitoring and strategic review to assess performance and outcomes from such approaches. This can help build community, implementer and funder confidence and enable processes to respond to emerging opportunities and challenges. It can also help to build more systematic strategic assessment and shared learning on the contribution of such approaches to structural and intergenerational dimensions of equity.

Enabling conditions beyond individual initiatives

The urban initiatives for health and wellbeing described in this paper suggest their potential contribution to different dimensions of equity. They also highlight, however, the limitations of local level action and authorities in producing change in policies, laws and other structural dimensions of equity. The deeper policy issues affecting structural equity cannot all be addressed at the local level, especially when policies are set by central governments and when wider economic trends, including global influences, affect and generate inequality. This calls for measures beyond the local level.

For example, a number of the initiatives nurture new forms of practice and generate, test and apply new, locally relevant and affordable technologies and methods that improve social, ecological and economic wellbeing. Technology and other innovations often

came from research and development by local universities, private sectors, technical, non-profit and public institutions, social enterprises and civil society, linking with communities to ensure the relevance and demonstration of innovations. However, this calls for funding of innovation, research and development and local demonstration and accessible and affordable internet and other infrastructures. While one initiative in Bwaise Kampala reported support from a domestic innovation fund, there was limited report of this, and more such funds seem to be needed.

Development aid and external project financing often provided a catalytic contribution to processes, but was also unpredictable and target-and time-bound. The sustainability and scale-up needed to have both wider and deeper impact, including on policy change, appears to depend more on local authority capacities and services and infrastructure, such as for pro-poor primary level health care, and for urban waste management, agricultural extension and other public services. Yet these services are often underfunded. While various forms of collective savings funds, seed and innovative funding measures and 'matchmaking' of private funders with specific groups were used to locally resource initiatives, these efforts cannot substitute adequate domestic financing of local public services and investment in the necessary local public infrastructure and local authority capacities for initiatives to flourish.

Documenting and communicating the changes achieved by initiatives, including to higher level policy and political actors, can help to build connections and alliances and to leverage wider attention, recognition and support. It can also enable exchange across practitioners, social and professional networks, within and across countries.

The paper provides evidence of a significant volume of inspiring and innovative local intervention for urban health and wellbeing, with many features supporting key dimensions of equity. Limitations found in better monitoring and documenting their distributional outcomes and pivoting from single issues to holistic and area-based approaches can be addressed at local level.

Addressing underlying drivers that emerge from the wider political economy and dimensions of structural equity that are controlled beyond local levels calls, however, for changes in national and international level policy, institutional practice and funding systems. If, as indicated in this paper, participatory and recognitional equity are key levers of equity-oriented change, then these dimensions should not be diluted as processes move from local to national and international levels, to profile local claims and experience, and to bring greater voice in such policy dialogue from local actors driving equity-oriented urban change.

Author contributions

RL prepared the analytic framework used in the work with external review input, prepared the synthesis of the desk review findings, carried out the thematic analysis, synthesised the findings and prepared the draft full manuscript, discussion and conclusions for review and input from GM, FG, SC, CW, and FG, co-ordinated and edited the final manuscript that all authors reviewed and signed off on, and prepared revisions to reviewer comments and co-authors reviewed the revisions. RL and GM carried out searches for the document review and identified the four cities and outline for the case studies with external review. SC, DG, CW, and FG implemented and wrote the case studies with review and edit input from RL and GM. All authors agreed to be accountable for the content of the work.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Broad Brush Surveys: a rapid qualitative assessment approach for water and sanitation infrastructure in urban sub-Saharan cities

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Introduction: Broad Brush Surveys (BBS) are a rapid, qualitative assessment approach using four meta-indicators -physical features, social organization, social networks and community narratives - to gauge how local context interfaces with service/intervention options, implementation and uptake.

Methods: In 2021, responding to rapid urbanization and the accompanying need for water and sanitation services, BBS was innovatively applied by social scientists and engineers to assess water and sanitation infrastructure, both formal and informal, in two African cities - Lusaka and Cape Town. In four urban communities, identified with local stakeholders, BBS data collection included: four mapping group discussions with local stakeholders (participants = 24); eight transect walks/drives; 60 structured observations of water and sanitation options, transport depots, health facilities, weekends, nights, rainy days; seven mixed gender focus group discussions (FGDs) with older and young residents (participants = 86); 21 key-informant interviews (KII, participants = 21).

Results: Findings were rapidly summarized into community profiles, including narrative reports, maps and posters, and first discussed with community stakeholders, then at national/provincial levels. The meta-indicator framework and set sequence of qualitative activities allowed the detail on water and sanitation to gradually emerge. For example, the mapping discussion identified water sources considered a risk for waterborne infections, further observed in the transect walks and then structured observations, which compared their relative condition and social interactions and what local residents narrated about them. FGDs and KIIs elaborated on the control of these sources, with nuanced detail, including hidden sources and the use of different water sources for different activities also emerging.

Discussion: We demonstrated that despite some limitations, BBS provided useful insight to systems and social processes surrounding formal

and informal water and sanitation infrastructure in and across designated urban areas. Furthermore, BBS had the potential to galvanize local action to improve infrastructure, and illuminated the value of informal options in service delivery.

KEYWORDS

Broad Brush Survey, water and sanitation infrastructure, Zambia, South Africa, meta-indicators, community-based research

1. Introduction

In sub-Saharan Africa (SSA), rapid urbanization has been driven by population expansion, migration from fragile states, rural-urban mobility, urban development and, more recently, COVID-19 related economic hardship (WHO, 2017; Ohwo and Agusomu, 2018; Simukonda et al., 2018; Enqvist and Ziervogel, 2019). This urbanization has been accompanied by an increase in unplanned settlements and added pressure on planned settlements, amplifying inadequate access to water and sanitation infrastructure (Ato Armah et al., 2018; Ohwo and Agusomu, 2018; Enqvist and Ziervogel, 2019; Priya et al., 2019). Rapid assessment of both infrastructure and access at community level, for pragmatic planning of water and sanitation infrastructure interventions, could help communities, municipal authorities and other stakeholders better manage water and sanitation delivery.

Cape Town, South Africa and Lusaka, Zambia provide an interesting comparison on urbanization. In Cape Town, as elsewhere in South Africa, service expansion and access initiatives are central to redressing the legacy of apartheid, and part of the government led Residential Development Programme (RDP) that has built houses for residents of informal settlements (Govender et al., 2011; Shackleton et al., 2014; Fransolet, 2015; Amin and Cirolia, 2018). Despite this investment, water and sanitation service provision has been confronted by vandalism, crime, misappropriation and shortage of public funds, poor quality and/or temporary infrastructure, low-lying and flood prone land, and water shortages linked to drought (McFarlane and Silver, 2017; Madonsela et al., 2019; Robins, 2019; Loubser et al., 2021). In Lusaka, 70% of the city's three million population live in unplanned settlements (Simukonda et al., 2018; NDP, 2022; UN Habitat, 2023). As unplanned settlements have continued to expand in Lusaka, formal service delivery has proved inadequate. Furthermore, the decentralization of water and sanitation delivery to local authorities and private companies (Chitonge, 2011; NWASCO, 2021), uneven and short-term development initiatives, and poor governance in the city have resulted in poor infrastructure and record keeping, inadequate maintenance (leading to water theft and leakage and unsafe infrastructure), and water-borne disease outbreaks (Chitonge, 2011; Kennedy-Walker et al., 2015; Loubser et al., 2021). Faced by inequitable access to formal services, residents of these two SSA cities often have to fill the gap left by government and non-governmental organizations (NGOs) by developing "informal" options and practices to access water and sanitation (Maryati et al., 2018; Nabirye et al., 2023). "Formal" and "informal" infrastructure can be distinguished by defining formal as infrastructure linked to governmental and NGO initiatives, and "informal" as alternative infrastructure initiatives that emerge in the communities alongside the formal (Maryati et al., 2018; Nabirye et al., 2023). The informal have often been left out of more conventional assessments of water and sanitation infrastructure.

Criticism against the Sustainable Development Goal 6 (SDG6) Clean Water and Sanitation has been widely raised, considering that access to safe water and sanitation are still lacking for 2.3 billion people and 4.5 billion respectively (Burton et al., 2021; Sutherland et al., 2021). A contributing factor to not achieving SDG6 is attributed to the slow integration of social and physical sciences to understand and improve water and sanitation management (Lund, 2015). Economic-social and economic-environmental linkages have received more attention than social-environmental (Rambaree et al., 2019; Mandelli, 2022). To gain a more comprehensive, contextual understanding of access to water and sanitation infrastructure requires using qualitative, local perspectives by utilizing the human-focused research approach of social sciences (Workman et al., 2021). Furthermore, integrating social sciences with engineering and physical sciences for water and sanitation could further help to facilitate social action and change to improve water and sanitation infrastructure and enhance wellbeing (Rambaree et al., 2019).

In this analysis, we integrate social and physical sciences in response to water and sanitation infrastructure challenges. We present the application of a rapid qualitative assessment approach, termed Broad Brush Surveys (BBS), by an interdisciplinary team of social scientists and engineers, to context-specific water and sanitation infrastructure challenges in Lusaka and Cape Town. Rapid data collection through adapted qualitative methods is not a novel concept, as social scientists have increasingly faced pressure to produce results within shorter timeframes compared to conventional ethnographic approaches (Sangaramoorthy and Kroeger, 2020). The BBS approach consists of a set sequence of qualitative data collection activities rooted in sociological observations of urban communities and focusing on four meta-indicators: physical features, social organization, social networks, and community narratives (Srivastava and Hopwood, 2009; Palinkas et al., 2015; Busetto et al., 2020). The application of this meta-indicator detail to the research question or public health issue at hand, and systematic comparison across geographically bounded communities within a short timeframe, has proved useful to informing study/intervention design, implementation and interpretation in public health research (Murray et al., 2009; Bond et al., 2013, 2016, 2019).

This paper contributes to the interdisciplinary body of knowledge on the interaction between growing urbanization in SSA cities, water and sanitation and their broader environmental implications. The importance of considering both the socio-economic and environmental factors when planning and implementing water and sanitation infrastructure projects in similar contexts is underscored (Frank et al., 2017; Priya et al., 2019). We argue that the BBS approach was pragmatic for demonstrating the eco-social and interdisciplinary value of this research. Further, the BBS approach also provided insights on community perspectives and reasons for using both formal and informal water and sanitation systems in four urban communities in Cape Town and Lusaka.

2. Methods

2.1. The Broad Brush Survey (BBS) approach and the meta-indicator framework

The study adapted a Broad Brush Survey (BBS) approach to assess formal and informal water and sanitation infrastructure in four urban communities, two in Lusaka and two in Cape Town. BBS aims to rapidly generate comparative community profiles for different disciplines and audiences around a key issue for the purpose of research and/or intervention. BBS uses a set sequence of qualitative activities and methods to gather qualitative data on four meta-indicators of a geographically bounded place: physical features, social organization, social networks and community narratives. During 5–15 days of fieldwork, the data from the sequence of qualitative activities are regularly debriefed by a research team (usually social scientists and local fieldworkers) and summarized, allowing for iterative interpretation and enquiry (Palinkas et al., 2015; Busetto et al., 2020). The research team thus builds a profile of the community to reach a more nuanced, although rapid, description that is revised and completed soon after fieldwork. The community profiles are then presented in brief outputs to share and discuss with relevant stakeholders. Following this engagement, the BBS data is more finely managed, analyzed and written up, sometimes being used in more mixed-methods analyses if the BBS is part of a larger research study. BBS often accompanies community engagement as one of the first activities of larger research studies, but can also be a stand-alone assessment for research or intervention.

Thus, the meta-indicators framework forms a multi-layered description that moves from a broad to a more focused understanding of the issue at hand both through linking each indicator to research specific detail, and by building a layered understanding of both the place and the specific research/intervention focus. Table 1 is adapted from Wallman et al. (2011) and summarizes the four meta-indicators. See also Bond et al. (2019) for the history of the BBS approach and the application of BBS within six public health studies in SSA, and see the BBS Manual v1 (Bond et al., 2023).

For this study, we aimed to demonstrate if BBS was an efficient and replicable approach to usefully gauge the relationship between local residents and water and sanitation infrastructure. We innovatively adapted the BBS approach to water and sanitation infrastructure with water engineers, who were involved from the concept onwards in the aim, objectives, tool content, graduate researcher selection and supervision, stakeholder engagement, fieldwork, analysis and dissemination.

2.2. Selection of study sites

Selection of sites was by pre-determined study criteria, background research, and thorough consultations with political and water, sanitation and hygiene (WASH) stakeholders. The study aimed to select urban communities within each city that were: a mix of planned and unplanned areas; sufficiently different to one another; new areas for each of the research institutes to work in; and identified by WASH stakeholders in each city as useful for broader WASH development issues.

Gray literature from sources of information, including, government reports, Google maps, and internet searches, were used to identify potential communities that fitted the study criteria. For each potential community, a profile was detailed that included: geographical boundaries and adjacent communities, ground area, the date the community was established, housing types, demographic profile, socio-economic characteristics, geographic topography, land utilization, services and resources, and identified issues and challenges. Thereafter, the study was introduced to and discussed with ward councilors and other municipal authorities, who then determined the final selection of communities. Through this selection process, we gained municipal approval to work in four communities anonymized as Z1 and Z2 in Lusaka, Zambia and S3 and S4 in Cape Town, South Africa.

2.3. Research team, training, and fieldwork time frame

In each country, a mix of social scientists and engineers were recruited as researchers, supported by more experienced researchers from both disciplines. BBS training was conducted remotely due to COVID-19 travel restrictions. The training took place over 10 days, with online sessions between 1 to 3 h, off-line practice session activities, and separate institutional ethical training in each country. The training included introduction to BBS, community entry and stakeholder engagement, sequence of activities and tools, core methods skills (observation, key-informant interviews, focus group discussions, mapping), core water and sanitation infrastructure in each country, ethics, data management, and report writing.

The fieldwork research teams consisted of a social scientist and engineering graduate pair and research assistants. In Zambia, Local Fieldworkers (LFWs) were appointed as research assistants to support the graduate pair with the fieldwork and were trained for a day in each community, and during the fieldwork itself. Having LFWs was useful to help the graduate social scientist and engineer to recruit research participants, accompany them on, and assist with, research activities, approach households in the community, and answer questions about the research. LFWs would also guide the researchers about language or cultural issues,

TABLE 1 Meta-indicators framework (adapted from Wallman et al., 2011, pp. 204–205).

Meta-indicator	Definition	Question relevant to problem management
Physical features	*"Material fabric of the local area"*. Visible, countable, mappable. Includes: housing types, other architectural features, employment and work options, physical boundaries, topography (bird's eye view).	What could happen here? What are the features of particular relevance to the problem?
Social organization	*"Relation of people to place"*. The organization of people in the place, across housing, work, mobility (access to transport, movement in/out of community). Characteristics of population diversity, age, ethnicity, family structure, socio-economic status.	How are people organized in this place? How are people organized in relation to the problem?
Social networks	*"Relation of people to people in this place"*. Links between people and groups. Patterns of interaction for example ethnic/local, chosen/ascribed. Extensive/intensive networks. Bonding/bridging social capital. Flexible/fixed network boundaries. Networks of services (formal and informal).	What are the patterns of interaction between people within and outside of the community? What networks are relevant and active for the problem?
Community narratives	*"What do people say about this place?"* Oral history (origin, style), identify with the place, commitment to the place (chosen/no choice), blaming patterns, butt of gossip.	What kind of place is this in local narratives? What are people's opinions about the problem?

help identify places of significance to WASH and alert where it was safe or dangerous to move around. In South Africa, research assistants were students from Stellenbosch University who attended the BBS training.

Between June and December 2021, the social scientist and engineering graduate pair in each country conducted BBS fieldwork with the research assistants in a period of 12–15 days in each study community. In both countries, the COVID-19 pandemic interrupted fieldwork in various ways including government and/or institutional closure of research during waves and/or lockdown and COVID infection and illness in study staff. When fieldwork took place, institutional COVID-19 Standard Operating Procedures and policies were followed and included regular testing of study staff, staff wearing masks, and providing participants with access to masks and hand-washing facilities, using well-ventilated spaces, and observing social distancing when inside structures. General elections and mourning period of a previous President further delayed fieldwork in Zambia.

2.4. Ethics

Ethical approval to conduct this study was granted by Stellenbosch University Ethics Committee in South Africa (reference Number N20/10/115); University of Zambia Biomedical Research Ethics Committee (Reference Number 1393-2020) in Zambia, the London School of Hygiene and Tropical Medicine (LSHTM) Ethics Committee (Reference number 25789), and the University of Sheffield (Reference number 042825) in the United Kingdom. In Zambia, additional clearance, and permission to conduct the study was obtained from the National Health Research Authority (reference number NHRA00001/31/05/2021) and Lusaka City Council. Written voluntary informed consent was obtained from all study participants above the age of 18 years. Young people below the age of 18 years gave voluntary informed assent before participating in the study. Additionally, written informed consent was sought from parents or guardians of young people below 18 years old who participated in the study. Photographs of individuals that were recognizable in the photograph were only taken and stored if written informed consent was obtained. Permission was sought for taking photographs of infrastructure that would identify a place using an explanation that photographs would only be used to provide visual aid to illustrate research findings. Likewise, verbal consent was sought when conducting community observations at places of significance to WASH in the communities. We disseminated research findings to stakeholders at both community and national level. This familiarized research communities with our findings and also gave them an opportunity to validate and discuss the findings.

2.5. Building a community profile

Once the communities were selected, we started to develop a community profile ahead of fieldwork activities. We transferred some detail from our background research to a template structured around the four BBS meta-indicators more generally and more specifically related to water and sanitation infrastructure. This draft community profile was expanded upon during fieldwork. Fieldwork activities were listed in the profile (activity name, date, participant type and number). We also created a base map of the community, which outlined the boundaries, main roads, and physical features. To create the map, we used online maps (Google Maps/Earth) to navigate and view the community using Street View. We then copied the map from the internet into Microsoft PowerPoint where we started to draw the outline, boundaries, and main features using the Shapes feature in PowerPoint.

2.6. BBS fieldwork

The sequence of the BBS activities is summarized in Figure 1 and the number and type of activities, participants and supporting tools in Table 2. Once approval was granted from relevant institutions and relationships developed with ward councilors, we started planning for the first fieldwork activity, the WASH stakeholder's discussion in each community. For this discussion, we intended to invite participants who would be knowledgeable about

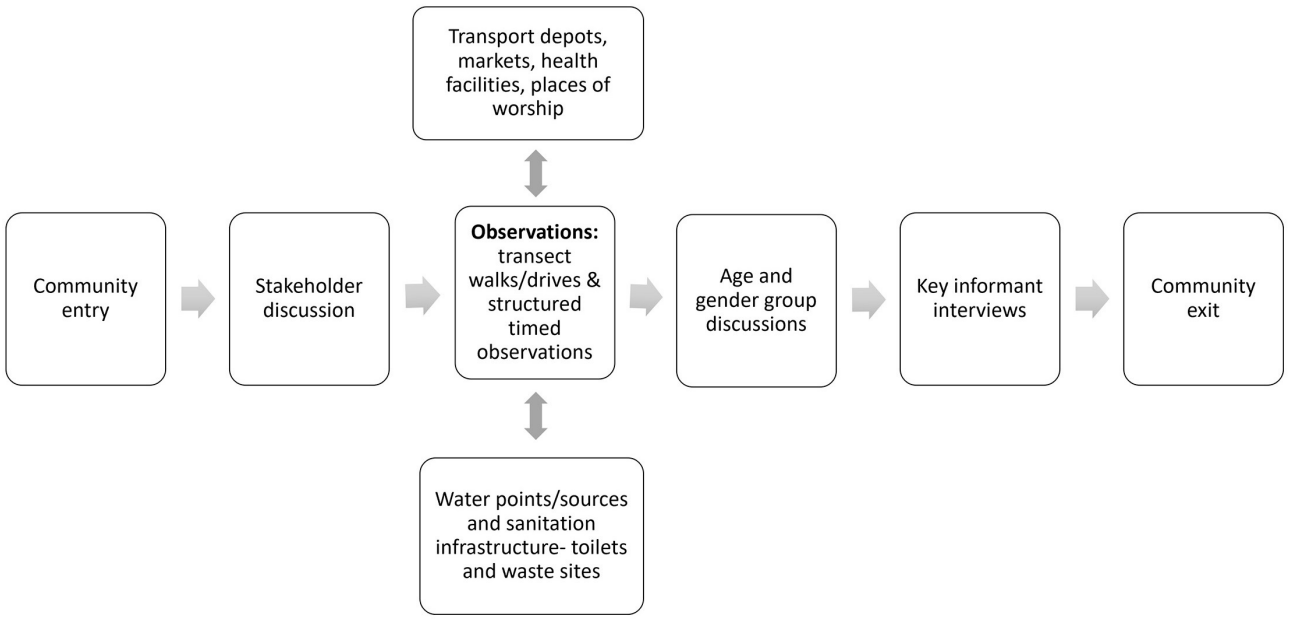

FIGURE 1
BBS sequence of activities.

WASH issues in the community and/or considered as leaders of the community. To mobilize participants for this discussion, we contacted potential participants telephonically (because of COVID-19), identified through contact lists or recommendations from local stakeholders. Most but not all potential participants were local community residents. The setting of the meeting had to be central or easily accessible for participants, and well-ventilated. This discussion centered around a mapping activity, where the boundaries of the community were discussed and verified, and places of relevance to WASH were located for the researchers to observe during the transect walk or drive, the second BBS activity.

The transect walk or drive was conducted immediately after the stakeholder discussion and on the following day. The large scale of geographic wards/communities and security issues in South Africa meant that this activity was primarily carried out by driving instead of walking. In Zambia, it was conducted by walking. The research pairs started walking or driving from a central point, stopping or getting out of the vehicle to observe the main features of the community, such as the types of housing, water and sanitation infrastructure, and people present. The researchers also visited water and sanitation infrastructure locations identified during the stakeholder discussion to observe the quality of the facility or infrastructure, take GPS coordinates and photographs, and make notes or sketches of the feature. In addition, places for structured time observations were noted down.

Structured timed observations were conducted as the next set of activities. The places of observation included key community facilities such as transport depots, markets, health facilities, places of worship, plus water and sanitation infrastructure locations (water points/sources, sanitation facilities including toilets and waste sites). Time was spent observing who is present at the locations, including the gender and age profiles of the population, and who was making use of different types of water and sanitation infrastructure. We had informal discussions with people at water and sanitation infrastructure observation locations to document their experiences.

The quality and usability of water and sanitation infrastructures and features were also observed through taking photographs and completing scorecards of the facilities. Aside from the set sequence of BBS qualitative activities, additional tools specific to the research issue can be added. We adapted and developed a water and sanitation checklist from the World Health Organization's (WHO) water/sanitary inspection package (WHO, 1997) (see Supplementary material 1). For each variable, the field researchers would observe what is present, classify the type of infrastructure, make descriptive notes about the structure/facility/source and its condition, ask more detailed questions to users about their challenges or preferences of facilities, and take photographs with the consent of users (if applicable). We then created a Likert scale from the checklist, with six parameters/themes, to score each water and sanitation facility based on their condition and suitability (infrastructure, location, access). For each infrastructure observed, we also derived an overall or total score, by summing up the individual ratings across the six parameters. The summation of parameter scores allowed us to assess and compare the holistic state of the observed water and sanitation facilities (Table 3).

Following the structured timed observations, focus group discussions (FGDs) were conducted with older groups of men and women and younger groups of men and women separately in community venues. The discussions focused on participant's experiences with water and sanitation infrastructure, WASH challenges, control of WASH resources, responsibility for services, and plausible solutions or recommendations for improved services and infrastructure planning. Through informal discussions during

TABLE 2 BBS activities, participant details, and data collection tools.

Activity	Number of participants and representation		Activity length and time	Data collection guide
	Zambia	South Africa		
Stakeholder individual or group discussion	• One group discussion per community • 11 women; 9 men aged 29–77 years • Environmental health specialists (EHS), water trust, community-based enterprises (CBEs), market cooperatives and local leaders.	• One discussion per community • Four men, who are long-term residents and community leaders (i.e., ward councilors).	2–3 h; morning	Stakeholder discussion guide
Transect walk/drive	• Four transect walks in both Z1 and Z2 communities, one in the morning and another in the afternoon per community.	• Four transect drives in S3 and S4, for approximately 2 h per drive.	2–4 h for each observation	Transect walk guide, general observation checklist, activity report form, GPS tracking sheet
Structured observations: entry/exit points, transport depot and other places of relevance	• Eight entry/exit point observations in Z1 and Z2 communities (four in each community). • Observations at the main bus stop, along a busy footpath in Z1 and at a busy junction on a landmark boundary in Z2. • One clinic observation in each community • One weekend and night observation in each community	• Ten entry/exit point observations in S3 and S4 (multiple neighborhoods) • Observations conducted at a transport depot/taxi rank in S4.	15–60 min for each observation	Transport depot: observation guide, data capture sheet, structured observation activity report form, observations of the health facility activity report form
Group discussion with older people	• One group discussion per community • 21 women; 8 men aged 18–63 years • Community representatives from different sections	• One group discussion per community • 12 women; 7 men aged 39–80 years. • Residents, leaders/stakeholders (neighborhood watches, community engagement groups, NGOs/NPOs)	2–3 h; afternoon	Age, gender group discussion guide
Group discussion with young people	• One group discussion per community • 13 women; 9 men aged 15–17 years • Representatives from different community sections	• One "on the spot" group discussion in S4 • 12 young women and 4 young men, aged 17–38 years	2–3 h; afternoon	Age, gender group discussion guide
Structured observations: water and sanitation infrastructure (scorecard)	• Six water point/source observations in Z2 • Four sanitation infrastructure observations in Z1 and four in Z2. • 1 rain observation in each community	• Ten water point/source observations (8 in S3 and 2 in S4) • Seven sanitation infrastructure observations (5 in S3 and 2 in S4) • Activities of collecting water in containers, cleaning parks/dumping sites/portable toilets/washing clothes, stormwater drain overflows	15-30 min for each observation	Structured observation guide and water and sanitation observation scorecard
Key informant interviews	• 8 interviews in each community • 7 women; 9 men aged 29–72 years • Ward development committee representatives, CBEs, water vendors, EHSs, teachers, community and religious leaders, WASH service providers and WASH facility owners.	• 5 "on the spot" informal key informant discussions • 3 women and 2 men • Community leaders and a communal tap user.	1 to 1 ½ h	In-depth interview guide

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TABLE 3 Water and sanitation scorecard parameters.

Parameters/themes	Score (0-very poor, 1-poor, 2-fair, 3-good, 4-very good)
1. Condition of water infrastructure/facility	
2. Physical condition of site	
3. Type of structure (temporary/permanent)	
4. Maintenance	
5. Availability/accessibility (public/private/shared)	
6. Location of facility relative to obvious sources of pollution	
Overall condition of facility (scale 0–25)	
(0–5-very poor, 6–10-poor, 11–15-fair, 16–20-good, 21–25-very good)	

the transect walks/drives and structured timed observations, we also recruited participants to take part in the gendered and age specific group discussions and key informant interviews. In Zambia, LFWs assisted with participant recruitment by approaching various individuals, households, and institutions in the communities. On the spot recruitment approaches in South Africa, meant that there were discrepancies with Zambian and South African age groups, especially with younger participants (15–30 years old). In Zambia, group discussions with young people were pre-arranged at venues. Whereas in South Africa, young people were approached on the street where they gathered, meaning that a wider range of young people participated.

The final BBS activities were key informant interviews (KIIs) conducted with knowledgeable individuals that had unique perspectives and experiences with water and sanitation infrastructure or service delivery. These individuals included prominent community leaders and community members that have lived in the community for a long time, residents or professionals who work or live in the community with adequate knowledge on and involvement in WASH. These interviews provided clarity and more details on issues that had been discussed during the FGDs.

Although this sequence of data collection was followed as described above, it was done slightly differently in both countries due to various implementation and institutional procedures. For example, in South Africa, data collection was conducted concurrently in the two study communities while in Zambia, data collection was first done in one community and written up, and then conducted in the next. In South Africa, some group discussions and interviews were conducted on the spot with participants. In both countries, during fieldwork, some days were spent away from the field to "build the picture" of each community, writing up the main findings in the community profile, writing up field notes, and adding meta-indicator layers to the community map (see findings and Supplementary material 2).

2.7. Rapid analysis

We rapidly analyzed data using a combined process of debriefing among field researchers, writing up the main findings from each data collection method into long community profiles of up to 20 pages, and plotting information on the community maps. These processes were done during and immediately after data collection took place. Short (four pages) and long community profiles were developed along with posters (A3) and maps (A0) including general and specific water and sanitation infrastructure findings for each meta-indicator.

2.8. Community and national level disseminations

The findings were first discussed with community stakeholders, including young people, WASH NGOs/non-profit organizations (NPOs), CBEs, community leaders/ward councilors, during half-day community dialogue meetings, aided by key messages developed from the findings (community and country specific) (Simwinga et al., 2016). Findings were presented using PowerPoint, pictures, community profile posters and maps. Community stakeholders reflected on the meaning and implications of the findings, and next steps. This process also allowed for researchers to verify that the information accurately represents the different perspectives in the communities. The findings were then shared at national/provincial levels, with community members present, where discussions included solutions to address WASH challenges.

2.9. Challenges in operationalizing BBS for water and sanitation

Security was a major challenge in both countries. In South African settings, safety concerns arose due to being in an unfamiliar, high-crime context. To address this, a driver familiar with the areas accompanied the researchers. These drives were included in the data collection, by pragmatically adapting the transect walk into a transect drive. In the Zambian setting, safety concerns triggered by a certain neighborhood in one community where there were alleged to be clandestine activities, and by political tensions surrounding a general election. The Zambian team addressed these concerns by avoiding either the identified neighborhood, and pulling out the field for a period, and always being accompanied in the field by a local fieldworker.

Obtaining research permission from political authorities was a new requirement for this study, unlike previous ones that only required approval from health authorities. Identifying suitable communities through background research led to consultations

with political authorities, such as ward councilors, for permission. In some instances, access was denied when no direct financial opportunities for the community were apparent, necessitating further research for suitable communities. Busy schedules of political authorities posed challenges, but most agreed to the research recognizing its importance in understanding water and sanitation issues.

Recruiting participants for group discussions proved more challenging in South Africa compared to Zambia, where some informal on-the-spot group discussions were employed that provided a general sense of community perspectives. However, forming coherent groups was difficult due to the non-formal setting, though participants expressed themselves more comfortably and open. Data collection faced delays and challenges, and additional buffer time was necessary in the planning process. COVID cases in South Africa led to cancellations of fieldwork, while in Zambia, staff falling ill and general elections caused postponements.

Analyzing data using the meta-indicators framework proved challenging for new researchers, particularly distinguishing social organization from social networks. Collaborative efforts with teams from both countries included reflective and debriefing sessions during fieldwork and write-up to ensure the findings were structured and organized accurately.

3. Findings

We first present our water and sanitation infrastructure findings using the meta-indicators framework, moving from physical features to social organization then social networks, and finally community narratives. In each of the four meta-indicator tables, in the latter order, and for each community, we first present a summary of the meta-indicator in general and then specific detail on water and sanitation infrastructure in the four selected communities. Refer to the anonymized map of Z2 in Supplementary material 2, which visually illustrates the findings along the four meta-indicators. Linked to each of the four meta-indicator descriptions, we depict the relationship between the meta-indicator and water and sanitation infrastructure across the two South African communities and then the two Zambian communities, before drawing out patterns across the four communities and two countries. After presenting each meta-indicator in turn, we show and reflect on which BBS research activities led to what findings about water and sanitation. Finally, we draw on the water score card, an additional observation tool we added to this BBS, to demonstrate findings on water and sanitation from this adapted research tool.

3.1. Community descriptions along the meta-indicators

3.1.1. Physical features—what are the physical/visible features of the general community and water and sanitation services?

See Table 4 for physical features and related water and sanitation infrastructure community detail.

3.1.1.1. S3 and S4 physical features and water and sanitation infrastructure

Both S3 and S4 exhibit socioeconomic and racial divisions, mainly along rivers and major roads. The middle-higher income areas have better access to formal water and sanitation options compared to the lower-middle income areas. In S3, both established and new informal settlements exist, with various water options available such as outside yard standpipes, communal standpipes, metered water kiosks, serviced plots, and portable toilets. In S4, formalized RDP housing areas coexist with backyard housing, resulting in more shared flush and tap facilities within yards or houses.

Both communities are located in peri-urban areas on the outskirts of Cape Town, where agricultural land is prevalent. Subsistence farming is practiced in these areas, alongside informal housing and a lack of WASH services. Residents and farmers in these areas rely on a limited number of water standpipes or water trucks provided by the government. In S3, there are illegal pipe connections to households in a farming community where communal standpipes are the only available water source.

Lower-middle income neighborhoods, including informal settlements and a mix of RDP housing and privately-built housing areas, have significant waste dumping sites in both S3 and S4. These sites are often found in open spaces, wetlands, and along canals/rivers. Waste is indiscriminately dumped, leading to stagnant water and blockages in stormwater drains, causing road overflows. Sewer blockages from waste are most prevalent in two S4 neighborhoods with a mix of RDP housing and backyard housing. In one farming neighborhood of S3, there are massive waste heaps upon entering the area. Adjacent to another subsistence farming community in S3, a canal connected to the river is polluted with solid waste, human waste, and sewage.

3.1.1.2. Z1 and Z2 physical features and water and sanitation infrastructure

Z1 and Z2 are socio-economically diverse and ethnically mixed, with planned and unplanned neighborhoods reflecting respectively middle- and lower-income social groups. Lower-income areas in both communities receive water from public service providers through kiosks and a few standpipes household connections. There are more informal and cheaper sources of water accessed by lower-income groups; in Z2, residents take advantage of water leakages from public infrastructure, and in Z1, residents use shallow wells (that are deemed illegal) and water from a large drainage with running water and a stream located within the community. Accessing water amongst the middle-income groups in the two communities differs. In Z1, the middle-income areas have water supplied to private taps in households through a public reticulation system and sewer system. Whereas in Z2, the middle-income areas largely rely on private and institutional boreholes to supply water to individual households, along with collecting water from communal public water points. Only the middle-income area in Z1 has flushable toilets and is mainly serviced by a public sewer system; groups in all other areas rely on on-site sanitation options. However, the type of toilets differ across socio-economic groups with the low-income groups in Z1 and Z2 using pit-latrines (traditional, ventilated), and the middle-income group in Z2 mainly

TABLE 4 Physical features—General and specific to water and sanitation in four communities.

Community	General physical features	Water and sanitation description
Z1	Z1 is located north of Lusaka; bounded by two main roads on the west and south, a stream on the north and a railway line on the east. It shares boundaries with four other communities. It is predominantly an informal settlement (small and clustered housing structures and unplanned roads) and a small section of the community with larger housing structures and commercial premises near a main road. Key amenities include three markets; one health facility and an NGO anti-retroviral clinic; two government, one community and several private schools. Additionally, there is a police post, the municipal council, TWT, offices for the main electricity supply company, and a filling station.	The Water Trust (TWT) (a community initiative pioneered by an international NGO) has four boreholes supplying water to the community through 69 communal water points (kiosks) and 450 household connections. Three private boreholes (two belonging to churches and one by the Islamic society) supplement water provision for free for residents. A large drainage constructed by a donor funded project to reduce flooding has running water from various sources. The stream on the north and the drainage have polluted water (either sewer waste, industrial effluent or solid waste disposed). Toilet options include pit latrines, flushable toilets in few community sections and five communal toilets. However, not all households have toilets leading to residents defecating in plastic bags or cartons, called "flying toilets".
Z2	Z2 is located south of Lusaka. It is a developing community with four distinct neighborhoods and is surrounded by other communities. Due to its developing nature, defining clear-cut boundaries is challenging even for residents. It is bound by a railway line on the west, extends into farmlands on the south, leads into other communities on the east and north. The southern part of the community is sparsely populated (houses sparsely distributed and large, with modern designs and beautiful landscapes) whereas the northern part (initial settlement) is densely populated with relatively older and smaller clustered housing structures that mostly have outdoor toilets. The community has two markets, a health post, two government, several community/private schools, lodges, churches, and a filling station.	The Lusaka Water Supply and Sanitation Company (LWSC) has two production boreholes in the community - one at the council office drilled by an international NGO and another at shaft five located to the south of the community. Water infrastructure run by LWSC includes a suspended tank, communal water points (kiosks) and private taps. There is one communal borehole at the main market and several drilled on private property by residents (predominantly in new settlement areas with sparsely distributed houses). Toilet options include flushable, pour flush and traditional pit-latrines. Environmentally friendly pit-latrines (with a fully lined substructure that can be emptied) were recently introduced through the Lusaka sanitation program. There are a few households without toilets. Push carts are used to collect and dispose of solid waste.
S3	Located east of Cape Town, adjacent to agricultural land, S3 has nearly 24 clustered neighborhoods stratified socially and economically into lower-income and lower-middle-income areas and divided by major roads. S3 has serviced informal settlements and newly constructed unserviced informal settlements, a major township and subsistance farmlands. Housing options include reconstruction and development program (RDP) government housing and privately-owned housing. A major river passes through the community.	Formal housing areas to the east have access to piped water and indoor flush toilets. A subsistence farming community south have no access to toilets and water except 3–4 water taps installed by the government. Access to water and toilet facilities vary on the west in the township and adjacent informal settlements, ranging from indoor flush toilets (RDP and privately built houses), portable toilets, outside metered water kiosks, water standpipes, communal flush toilets/taps (informal settlements), and government provided plots with concrete flush toilets and a metered water basin (serviced plots).
S4	S4 is located in the Cape Town metropole, to the east surrounded by major roads and some open agricultural land. It has 10 neighborhoods clustered as a political ward. A major river runs through S4, dividing the lower-income and middle-higher income areas. Housing options include a mix of formal privately owned houses, townhouse complexes, RDP housing and widespread backyard informal housing.	Access is provided to all communities in the form of piped water and indoor flush toilets. However, access is not equally distributed (lack of equal distribution is particularly seen RDP areas on the west). These RDP settlements are particularly prone to flooding and blocked drains, as a consequence located close to the river. Some houses in middle-higher income neighborhoods to the east use borehole water as well.

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using flushable or pour flush toilet facilities that use septic and soak-away systems. In Z1, the use of "flying toilets" (defecation in plastic bags or paper cartons) was reported.

Solid waste disposal is a challenge in both communities. There are no designated waste disposal areas in the two communities. The challenges of solid waste disposal are worse in the unplanned neighborhoods that are densely populated compared to the planned neighborhoods. Challenges with solid waste disposal in the densely populated areas can partly be attributed to lack of access to roads for solid waste management companies. The community boundaries (in or along the stream, drainage, and railway line in Z1) and along the railway line in Z2 are the places where solid waste is disposed. Other places where solid waste is disposed include open spaces along the roads and in drainages in both communities. In Z2, solid waste is also disposed in unoccupied buildings that are under construction, near a football field, and some residents dig pits for waste disposal. Clogged drainages are common due to improper waste disposal in both communities.

3.1.1.3. Cross-country comparison of physical features and water and sanitation infrastructure

In all four communities, the formal water supply systems were insufficient to meet the demand as governments struggled to expand service delivery. Compared to South Africa, the Zambian communities had fewer households supplied with piped water using a reticulation system. Drawing water from cheaper or free sources was common practice amongst lower-income groups, and included damaged public infrastructure. Indeed, damaged water infrastructure was visible in all communities. Likewise, new toilet designs were evident in lower-income areas, with many also having maintenance challenges, for example, emptying sludge. In all four communities, flush toilets of varied design were usually located within houses and sometimes outside in a separate building. The flushing system was not always functional due to poor water supply systems or damaged flush parts, forcing residents to pour water to flush the toilets.

Disposal of sewage sludge was a challenge and a health risk in all study communities. Open areas and water courses provide space for dumping, but dumping also occurred in cramped spaces. There were clear inequities in access or ability to access water and toilets across middle- and lower-income groups in all four communities. Although lower-income areas were more impacted by dumping, open space could also be located near to or in middle-income areas, and solid-waste disposal challenges were apparent across all groups.

3.1.2. Social organization—what are the relations of people to this place?

Table 5 convey the social organization features and the water and sanitation infrastructure in the selected communities.

3.1.2.1. S3 and S4 social organization and water and sanitation infrastructure

In both S3 and S4, lower-income areas face challenges sharing facilities and infrastructure due to dense populations. The portable toilets provided by an outsourced/tendered company are maintained by employed workers, mainly local residents who are women. In S4/s low-middle income neighborhoods with backyard housing, indoor and yard water/sanitation facilities are shared, straining infrastructure designed for one household per plot. Water is metered by water management devices in lower-middle income areas in both S3 and S4, affecting daily water accessibility and driving a practice to access free water elsewhere. In S3/s farming area, neighboring residents collect water from limited communal taps to save costs on private usage. In the other farming area, water is collected from nearby informal settlements with communal facilities. Furthermore, unplanned informal settlements in S3 face water scarcity, leading residents to collect water from those with private serviced plots nearby. Government-led efforts in both S3 and S4 involve employing community members through the Expanded Public Works Programme (EPWP) for short-term employment in waste clearing.

3.1.2.2. Z1 and Z2 social organization and water and sanitation infrastructure

Z1 and Z2 have distinct water service providers, the Water Trust (TWT) and Lusaka water supply and sanitation company (LWSC), supplying water through communal water points (kiosks) and household connections. Local residents are employed at kiosks. In Z1, both planned and unplanned neighborhoods receive water from TWT, while in Z2, LWSC mainly supplies the unplanned neighborhood. Religious organizations operate three boreholes in Z1, providing free water, while a religious organization charges for water in Z2. There is an informal economy of some institutions (for example a garage in Z1) and households charging to share public service water, and alternative water sources (for example shallow wells in Z1).

Solid waste collection and disposal are managed by community-based enterprises (CBEs) in both communities. However, the CBEs struggle with collection of solid waste due to lack of resources (transport, financial and human), attributed mainly to residents failing to pay for solid waste collection. As a result, residents dispose solid waste in undesignated spaces in the community and engage illegal dumpers who charge less and perpetuate the problem of indiscriminate waste disposal. In Z1, the CBE collaborates with TWT in solid waste management through the bundling system (for every $2.60 paid for water, 52 cents is for solid waste management). The CBE in Z2 has a robust solid waste management system at the dumpsite where primary and secondary sorting of solid waste is conducted for the purpose of recycling.

Densely populated low-income areas in both communities share toilet facilities and agree on cleaning duties or a fee. In Z1, manual desludging of filled up toilets by residents is common. Both communities have benefitted from developmental projects aimed at improving sanitation facilities. In Z2, LWSC through the Lusaka sanitation program benefitted from the construction of subsidized VIP pit latrines with a fully lined substructure while in Z1 pivot toilets with a septic tank that separated urine and fecal matter for recycling purposes (fertilizer production) had been introduced.

3.1.2.3. Cross-country comparison of social organization and water and sanitation infrastructure

There is a mix of public delivery of water that is metered across all communities and some commercial delivery of water in South African communities, paid for by municipalities. Institutions and commercial premises in Zambian communities, and households

TABLE 5 Social organization - general and specific to water and sanitation in four communities.

Community	Social organization–general community	Social organization–water and sanitation
Z1	Low-income areas are densely clustered compared to the middle-high income areas. Residents settle near their livelihoods. Minority racial groups (Somalis and Indians) have settled near wholesale premises where they trade, while local traders have settled near markets. Residents in formal employment and others conducting businesses outside the community commute either by foot, mini-buses, or bicycles. Charcoal traders are the identifiable transient populations at one market. Public service providers include a health facility, police, and TWT.	TWT controls access to potable water through kiosks (US$2,59 per 20ℓ container) and household connections (billed monthly via a meter). Water vendors regulate kiosk access and maintenance. The drainage, stream, and shallow wells serve as alternative water sources. Shallow well water is accessed for free or at a minimal charge per month. Water from the drainage and stream is free. Communal toilets help improve sanitation and generate revenue for TWT and market cooperatives. Three community-based enterprises (CBEs) collaborate with TWT in solid waste management through the bundling system (for every US$2,59 paid for water, 50 cents is for solid waste management).
Z2	Z2 has diverse Zambian ethnic groups. The sparsely populated middle-high income areas offer expensive housing. The densely populated initial settlement houses mainly low-income residents. Residents from middle-high income areas are mostly in formal employment, while the lower-income settlement residents mainly engage in market trading and small businesses. Mobility is routine, with residents leaving and re-entering the community for school and different livelihood options, often busier in the morning and evening. Seasonal mobility is linked to farming.	In the low-income settlement, households connected to LWSC have personal standpipes with fixed or metered monthly bills. Water vendors at kiosks charge 10c/20ℓ container, and some kiosks originally designed with a token system have been replaced with taps. Private boreholes are used by some residents and a market cooperative manages a communal borehole for traders and residents. The community uses on-site sanitation. Solid waste is either burnt, dumped in pits at households, kept in bins (awaiting collection) or dumped in illegal dumpsites. A CBE charges US$2, 54–$3,57 to collect solid waste using push carts and a truck, transporting it along the railway line to a dumpsite. At the dumpsite, primary and secondary waste segregation occurs before disposing of non-recyclable waste.
S3	Most residents are colored[a] (in the east), living in private and RDP housing. Black Xhosa and African foreign nationals live in formal and informal housing to the west. Colored neighborhoods have multi-generational houses, while the informal settlements have younger populations. Christianity is the predominant religion. Subsistence farming areas are occupied by foreign nationals employed by landowners, some living here despite having formal housing nearby. Informal employment (vendors, tuckshops, shebeens, small-scale farming) is prevalent in the west, while the east is dominated by formal employment (shopping malls, industrial areas). Minibus taxis are the main mode of transport, mainly used by women commuting to retail or domestic work.	Residents with private homes (east) are charged for water usage and the more people/houses per plot, the higher the water bills. Whereas RDP houses have water meter restrictions of around 350ℓ per day. Residents with serviced plots in informal settlements have limited metered water at ∼130ℓ per household daily, compared to other households limited to 100ℓ per blue metered kiosks, and 20ℓ, 8 times a day for outside standpipes. Newly constructed informal settlements have no access to water and toilets and resort to open defecation and walking long distances to access a standpipe. Residents from unplanned farms to the south-east only have access to 1 functional communal standpipe. The government also provide water bowsers to the farm areas daily. Farm residents also collect recyclable materials that are scattered on the farms to sell to companies outside for an income.
S4	The majority of residents are colored, followed by black Xhosa and African foreign nationals. The north-eastern areas have white and colored residents representing middle to higher-income groups. Backyard housing is prevalent in the west with a younger population. Christian and Islamic religious institutes are dominant. Industrial areas and agricultural spaces provide job opportunities, and residents often commute outside for work. Middle-higher income areas access private car transport, while minibus taxis are used in the west.	Government-employed waste collectors/street cleaners are mostly local residents. Water and sanitation services are generally determined by where individuals are located in the north-west, with some sections or streets having only outside flush toilets and taps; the rest have indoor toilets and taps, shared by multiple households. Similarly, south-west residents in backyard housing are dependent on main houses for these services, leading to overuse of facilities. High reports of illegal dumping of waste near the river and wetlands.

[a]The term "coloured" refers to racially mixed or "people of colour". Despite the end of apartheid, race still significantly impact the lives of most South Africans, remaining a prominent model for social organisation and identity (Finchilescu and Tredoux, 2010).

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in all communities, will sometimes raise funds by selling metered water they have paid or borehole water to other residents. NGOs and religious organizations play a key role in the implementation of water and sanitation interventions. Dumping of solid waste in South African communities was organized by outsiders, whereas in Zambian communities, the illegal dumpers were local residents. Water, sanitation and solid waste management run by public and private bodies and households creates both formal and informal employment and/or raises income for both men and women, although in Zambian communities, most of these opportunities were for men.

3.1.3. Social networks—what are the relations of people to people in this place?

Table 6 convey the social network and linked water and sanitation detail in the community.

3.1.3.1. S3 and S4 social networks and water and sanitation infrastructure

Economic difficulties lead main house owners to rent out backyard space in S4, mainly to foreigners at around $19 per month. Approximately 4–6 backyard households share water and sanitation facilities in one main house or yard. In S3, the rise in new informal settlements is driven by economic opportunities in the city. In informal settlements and farming areas, residents with better access to water often share communal water taps with those who lack access. High demand from population growth leads to more households sharing limited facilities, and newly settled residents access water from neighboring areas.

In S3, communal toilet blockages take up to 4 days to be fixed, leading some to assign specific houses for toilet use, locked with padlocks. In S4, multiple households sharing one toilet often face regular breakages, with lengthy waiting times for repairs or being asked by the municipality to hire a plumber themselves. Sharing households are all responsible to clean after themselves and use gray water or containers to flush when the toilet is broken. In S4, EPWP-employed workers clear waste daily from an open space, while young residents collect waste near dumping sites to protect children playing. A Rastafarian leader in S3 actively encourages cleanliness, especially around his vegetable plot and crèche. Residents generate income by selling recyclables to outside companies through waste picking on farms.

3.1.3.2. Z1 and Z2 social networks and water and sanitation infrastructure

In both Z1 and Z2, networks revolve around sharing of water sources, water collection containers and the means of collecting water. Residents in both communities form networks through collection of water from communal water points. In Z2, sharing or hiring containers for drawing water (drums) and pushing drums at a fee has created networks among residents. In Z1, other networks emanate from sharing alternative water sources such as the shallow water wells, scoop wells, drainage, and the stream. In Z2, residents with private boreholes have created networks with those that do not have by supplying water to them at a fee.

In both communities, sharing of toilet facilities (influenced by lack of toilet structures, proximity of households and interpersonal relationships) has created networks among community members who agree on the terms of toilet sharing. In Z1, networks are formed among residents who own toilets and those who offer manual desludging services for filled up toilets. In both communities, networks also exist among residents and illegal waste collectors who offer cheaper solid waste disposal services in the communities. In Z2, residents have also formed networks with individuals who dig solid waste pits within their premises. The CBEs in both communities foster networks by employing residents to collect solid waste. In Z2, the CBE further created networks among casual workers who sort and segregate solid waste into types, solid waste aggregators who bring empty bottles and plastics to exchange for money and manufacturing companies who buy recyclable waste.

3.1.3.3. Cross-country comparison of social networks and water and sanitation infrastructure

Employment networks are linked to water, sanitation and solid waste management in all the four communities; with employment being both casual and formal, and employers being public service organizations and private enterprises or individuals. Sharing toilet facilities is common across all communities and is not always an economic transaction. Networks across community/neighborhood boundaries and income groups are formed in the process of accessing water. There are some striking examples of community action in response to solid waste management in the South African communities.

3.1.4. Community narratives—what do people say about this place?

Table 7 summarize the community narrative and linked water and sanitation infrastructure community detail.

3.1.4.1. S3 and S4 narratives and water and sanitation infrastructure

Narratives convey that S3 and S4 communities voice their experience in housing, water, and sanitation services including residents waiting for proper housing and basic services, and inadequate infrastructure, leading to water cuts, low pressure, and overflow problems. In S3, residents focused on how water availability is strained by people from other areas collecting water in serviced settlements, while in S4, increased population sharing limited water resources was voiced:

> "*The challenge is that people from other areas come and collect water from here. People do not follow the rules. For example, they put the bucket on top of the tap, and then the tap breaks*". (S3, Stakeholder discussion).
>
> "*We receive 350 liters of water with 5 households living on the yard. One hour later the water is cut, then we have to use washing water for the toilet (gray water). We have to inform everyone on the yard when you will do your washing*". (S4, young FGD)

Additionally, in S3, some residents explained how they still use buckets for defecation due to the lack of planned services in certain areas, while in S4, poor sewerage drains and pipes was said to lead to sewage overflow:

TABLE 6 Social networks–general and specific to water and sanitation in four communities.

Community	Social networks–general community	Social networks–water and sanitation
Z1	Z1 Health center and the NGO ART clinic foster networks by offering healthcare services and opportunities for voluntary work to residents and outsiders. Trading networks form as residents buy, sell goods, and share trading spaces in wholesale shops and markets. Wholesale businesses provide employment connections and foster relationships across minority racial groups like Indians, Somalis, Rwandese, and local residents. Somali and Indian residents bond through a common belief in Islam, while other residents meet at respective churches. Networks are formed through shared interests at bars, lodges, salons, barbershops, and playing football.	TWT creates an extensive network through community water vendors, communal toilets and their custodians as well as the CBEs. Likewise, sharing of water from water wells creates a network between users. Sharing toilets among households that have toilets and those that do not have creates networks, influenced by proximity, interpersonal relationships, and the responsibility of maintaining toilets. Other networks are developed from manual desludging services offered by residents who use buckets to empty filled-up pit-latrines.
Z2	Residents in the low-density areas are connected through employment such as car wash businesses, farming, and the presence of shops. Similarly, residents in the high-density area have formed networks through trading at the market, common interests, and shared religious values.	In the low-density area, residents form relationships by sharing water from boreholes. Those without boreholes connect pipes to households from individuals or institutions (church, clinic) for a fee or draw water in drums or 20ℓ containers. Water drums are also shared/hired for collecting water. Adolescents/young people and women push water drums from water points to households to earn money. Toilet sharing is common, influenced by proximity, relationship, lack of facilities. Solid waste management networks include, casual workers who sort solid waste, solid waste aggregators who exchange empty bottles and plastics for money, manufacturing companies who buy recyclable waste. Some residents engage unauthorized "dumpers" to collect and dispose solid waste in undesignated spaces at negotiable fees (US$1,29-$2,33) or dig garbage pits within their premises.
S3	S3 is characterized by intertwined township & informal settlement areas with blurred boundaries. Residents are connected through migrant status and ties to the Eastern Cape, fostering extensive communal support for informal businesses. The predominantly colored area, where multiple generations live together, has newly developed RDP housing primarily provided to outsiders. In this area, the neighborhood watch ("the walking bus,") consisting mostly of elderly women, plays a significant role in keeping the youth away from gangs.	Informal settlements with higher water restrictions received uncontrolled standpipes; serviced plot residents complain of visitors from the decanting site collecting water. Farmers near serviced settlements access communal taps, leading to breaks due to high demand. South-east farm residents accuse wealthier neighbors of collecting multiple containers of water from working communal standpipes and attribute theft and tap damage to drug users. Open defecation occurs in farm areas and new informal settlements without sanitation infrastructure. Temporary settlements use more maintained portable toilets instead of communal flush toilets. Some residents implemented a system to assign households to specific communal toilets controlled by a padlock.
S4	S4 faces challenges, with one neighborhood divided among rival gangs, making it difficult for residents to move around safely and police patrols are evident. Elderly individuals have better connections with gangs and can negotiate safe passage. Gang recruitment of young people for drug sales is common. Another low-income neighborhood shares a boundary with a more affluent sub-area where residents prefer not to mix. Service delivery is further constrained by gang territories.	In addition to EPWP workers, concerned citizens proactively pick up waste daily despite ongoing waste dumping in the north-east area. Younger residents living near the dumping site collect waste to prevent drain blockages, directly impacting their health and the health of their children. Residents south-west face challenges with their drainage systems due to close proximity to wetlands and the river. RDP houses, and title deeds, were provided to residents providing they sustained maintenance. To address blocked drains and sewage-filled streets, residents lodge complaints with the local municipality.

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TABLE 7 Social narratives–general and specific to water and sanitation in four communities.

Community	Narratives–general community	Narratives–water and sanitation
Z1	Z1 emerged as an informal settlement in 1957 with illegal settlers building mud houses along the periphery of a farm that was owned by a white couple. After independence, the city council was mandated to provide services. However, public service provision has only been improved in the last 20 years. Poverty and crime were identified as community challenges.	Originally, people accessed water through public taps. In 2002, an international NGO established TWT to address water and sanitation challenges in the unplanned settlement. Limited space made constructing new toilets & communal water points a challenge. In 2003, pivot toilets with septic tanks for removal of recyclable sludge to produce fertilizer were introduced but proved unviable. Residents use TWT's water for drinking and alternative water sources for other uses to reduce bills. TWT provides free water to bereaved families during funerals. Use of shallow wells is secretive given the local authorities' efforts to ban their use. Some residents feel neglected by the government due to poor service provision.
Z2	Residents have different stories about the origin of the name of the community but have consensus that it was attributed to the development that transpired in the community. The first settlers lived in the densely populated area of the community, reputably a farm that was owned by a Boer farmer. The whole community has been growing over time and sub-communities emerged.	Historically accessing water has been a challenge as the council's supply was insufficient for the whole community. In 2013, LWSC started supplying water and in 2015, the utility company received a grant to drill a borehole, set up kiosks, &repair dilapidated water systems. However, on-site contamination of underground water, threatens ground water quality: one borehole funded by the grant was abandoned. Some areas offer "free water" through old kiosks with the token system removed. A community volunteer oversees this water point where residents fetch unrestricted water and pay US$1,02 for damage maintenance. Residents are informed on prevention measures during water-borne disease outbreaks.
S3	The Township originated as a hostel for black laborers during apartheid & has now become densely populated with new informal settlements. The rise of informal settlements is linked to the negative economic impacts of COVID-19. Clashes between the government and settlers occur when houses are demolished due to the lack of planned services. Plans to construct 2,500 homes on the south-east farms, currently occupied by long-term residents, have sparked requests for better services where they currently reside. In the north-east predominantly colored area, pervasive gangsterism contributes to crime in open spaces.	Circa 10 years ago, some informal settlements in the township acquired flush toilets and standpipes. However, the township faces water cuts lasting up to 6 h on weekends, with low pressure upon its return. Water scarcity is exacerbated by people from other areas collecting water, leading to broken taps. The serviced area is on dry land, while other informal settlements are flood-prone, resulting in prioritized serviced plots for some settlements. Serviced areas still experience drain overflows during the rainy season. COVID-19 has further delayed water and sanitation service delivery. The older colored-majority area experiences pressure on drains due to new housing constructions. Backyard residents with private toilets mention that others see these homes as temporary and lack the means to install their own toilets and taps. Farm residents claim neglect by local authorities (only water standpipes installed despite promised housing in 2018).
S4	In the south-west RDP area established in the late 1990s, bribery for housing allocations (US$390) by government officials was reported. Residents attribute challenges in housing, education gaps, psychological services, and water to the government. Gangsterism is associated with economic opportunities for school dropouts, and restricts access to services, worsening social ills. In the north-west RDP area, residents strongly express discontent about overpopulation, linking it to corruption and job losses during the COVID-19 pandemic. Limited opportunities in create a sense of hopelessness.	Residents face stormwater overflow and flooding in their houses due to substandard construction of sewerage drains and pipes in the south-west. Health risks are associated with the polluted rivers, wetlands, and drains, believed to contribute to cancer & TB for some residents. Frequent drain blockages cause unsanitary smells in the north-west. Roads are poorly maintained, with potholes filled with stagnant water. Younger residents blame foreign nationals for wasting water and resources.

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> "*People defecate in open areas or buckets. It is unsanitary since some younger residents knock over the feces.*" (S3, informal KII)
>
> "*The houses share water and sewerage pipes. When the pipes are blocked at one house, it causes an overflow at another house. We cannot plan or build anything on our plots because of the poor design of pipes underneath.*" (S4, older FGD)

Both communities were acutely aware of facing service delivery inequalities, with certain areas being identified as receiving more attention and resources. In S4, wealthier neighborhoods to the east were pointed out by the informal settlement residents as having better infrastructure design to maintain the river flow. Whereas in S3, farm residents feel neglected by local authorities, as housing promises made only resulted in water standpipes being installed in 2017. Limited access resulted in broken or occupied communal standpipes.

> *"When it rains you cannot cross the river because it overflows. For people living higher up the river, the canals are built higher which prevents overflow. Over here, the river is not being maintained."* (S4, young FGD)
>
> "*In 2017 water standpipes were established when new pipes were laid underground. Some of the people stole the pipes underneath the ground and then the water pressure dropped completely because they connected their own pipes. A water valve was installed that only allows a certain percentage of pressure for water to come through.*" (S3, Stakeholder discussion)
>
> "'*White' (privileged) people fill up containers full of water so that they don't have to pay for water at their homes.*" (S3, Informal KII)

The influx of people affects housing availability and maintenance in both communities, with some blaming outsiders who move into new RDP housing, political sabotage of service delivery and foreign nationals for resource waste:

> "*We never used to have problems with drainage, only when they started to build new houses over there in [sub-neighborhood of S3]*". (S3, older FGD)
>
> "*Today you will clean, tomorrow there's new waste that were dumped. All this dumping is about political control because there is currently a battle about controlling the ward. Political rivals try to gain points from people when they clean spaces, hence the dumping occurs*". (S3, older FGD).
>
> *"The foreigners can waste water. They do their washing and cook the entire day. They have more water than us. They live all over."* (S4, young FGD)

3.1.4.2. Z1 and Z2 narratives and water and sanitation infrastructure

Both Z1 and Z2 shared their history of emerging as unplanned settlements from farms and their historical challenges with water and sanitation services. The main water service provider was reported to not be able to meet the demand of the rapidly growing population in both communities.

> *"….there are still areas that are not serviced because these peri-urban areas expand every day and the rate of urbanization is expanding is not matching service delivery". (Z2_KII)*

In both communities, residents from low-income houses shared their challenges in meeting the cost of water.

> *"Lack of money is a challenge for people to access water and sanitation because some people cannot afford to connect pipes in order to have standpipes and others cannot afford to pay at the water points". (Z2_KII)*

This pushes them to resort to alternative and unsafe sources of water – shallow wells, water from the drainage and stream in Z1, and water from leaking pipes in Z2. In both communities, the use of alternative sources of water is secretive as it is illegal. Some community members in Z1 justified the use of alternative sources of water, saying, *"water does not kill,"* hence they could use the alternative sources of water without anticipating any challenges.

> *"Someone would say I have been here for years, drinking this water and am here, am good, what can you tell me". (Z1, KII)*
>
> *"As long as there is intermittent supply of water, people will always resort to shallow wells". (Z1, KII)*

Abandonment of water sources due to a risk of ground water contamination was narrated linked to public service boreholes in both communities and private boreholes in Z2. Residents in Z2 also pointed out that privately owned boreholes are considered unsafe due to lack of testing for impurities.

In both communities residents expressed dissatisfaction with the CBEs for not being able to collect solid waste, and in Z1, the bundling system was reported as not able to working effectively.

> *"The challenge with garbage collection was that most people did not want to pay money for their garbage to be collected but would still take their garbage to the pick-up points". (Z1, KII)*

The lack of toilets in Z1 was linked to the lack of space to construct toilets due to over population and limited resources among some residents who could not afford to construct toilets, which sometimes led to defecating in the open or plastic bags.

> *"At home, most people use personal pit latrines and those that do not have toilets use their neighbors if they talk to them or have some sort of friendship". (Z1_Young FGD)*
>
> *"When someone has diarrhea, they have to ask from those with toilets. It is common to find people have defecated in plastics or by the corner of building that is less busy….some people also use the stream as a toilet and defecate in the open or while others go there to throw human feces". (Z1_KII)*

Although both communities have had developmental projects aimed at improving the supply of water and sanitation, development initiatives are sometimes reported to have been unsuccessful. For example, in Z2, the newly introduced subsidized environmentally friendly pit-latrines (with a fully lined substructure that can be emptied) through a donor funded

program have been received with skepticism by some residents who consider them likely to fill up quickly compared to the ordinary pit latrines.

3.1.4.3. Cross-country comparison of community narratives and water and sanitation infrastructure

In all four communities, local residents voice their frustrations and lack of dignity and a feeling of neglect in the face of limited water, sanitation and solid waste infrastructure. In South Africa and Z1 in Zambia, local residents tended to blame the government or outsiders. Overall, there is a stronger reliance on the government to "fix" things in South African communities, as opposed to Zambian communities being more self-sufficient. In both Zambian communities and S3 in South Africa, local residents also blamed better off residents for exploiting worse off residents through a pattern of re-selling water. All communities were eager for interventions to improve their water and sanitation infrastructure and solid waste management.

3.2. Data sources for water and sanitation options

Table 8 reflects the data sources for the different water and sanitation options in each of the four communities. This over-view of data sources reflects the importance of having a mix of qualitative methods—observations, group discussions, key informant-interviews. It also illustrates as the value of particular participatory techniques, particularly mapping, and of adding new tools to the core set of BBS research tools since the water score card is often a data source. Moreover, the table reflects how information on the specific infrastructure emerged in the sequence of the BBS approach, with most being informed by a combination of methods. We use two examples from Zambia and South Africa to illustrate this point.

3.2.1. Example 1: shallow wells in Zambia

Shallow wells were first mentioned in the stakeholder mapping discussion as an alternative water source and hotspot for water borne diseases. They were later observed in the community by researchers during the transect walk and researchers found that residents were not open to talk about shallow wells, with their location and use being regarded as a secret subject due to them being prohibited and sometimes filled in.

> *"Burying of the shallow wells is a challenge as they complain that they do not have water...the buried shallow wells are usually unburied proving to be a challenge to control".* (Z1, KII)

In both the young and older mixed-gender discussion, participants mentioned that some residents pay 50 cents (USD) a month to the shallow well owner to access water while other shallow wells were free of charge. It was later revealed during the KII interviews that these wells were banned in the community during the 2018 cholera outbreak in Lusaka. Further, it was also revealed during the water score card observations that the water from these wells were used for other households' activities and not for cooking and drinking and provided a strategy to cushion the cost of water and manage intermittent water supply.

> *"People say water does not kill and that is why they use water from the shallow wells despite being told that it is contaminated".* (Z1, Young FGD)

3.2.2. Example 2: portable toilets in South Africa

During a mapping stakeholder interview, we learned about an informal settlement in S3 that is regarded as a temporary relocation settlement. People here are awaiting to be moved to receive serviced plots (including water and sanitation facilities) through title deeds. In their temporary location, they received shared water kiosks, standpipes, and portable toilets. When we visited the settlement during a transect walk, we observed a few rows of portable toilets along a road located opposite the site. Asking residents on the street, we learned that about 4-6 households must share these facilities. Community leaders, during a stakeholder/key informant discussion, explained that the portable toilets are looked after to avoid misuse of the facilities. When they are blocked, the residents send an SMS to report the problem. This leads to the porter potties being replaced if they are beyond repair. The leaders confirmed that the toilets are used by temporary residents and cleaned daily by locals who are hired by the government and the waste is collected by trucks daily:

> *"The temporary toilets are cleaned daily. These toilets are used by the people who are waiting for the serviced plots to be installed."* (S3, Stakeholder discussion)

During the water/sanitation scorecard observation, we saw two government-employed women cleaning the toilets using chemicals and brooms to clean the surface area. The toilets were tilted to let the excess cleaning water flow out from the porta toilet. No locks were present outside the toilets, but the toilets can be locked from inside.

3.3. Additional methods in the BBS—water and sanitation scorecard

The water scorecard was integrated into the BBS sequence to enhance data collection and interaction with infrastructure, complementing other methods. The scorecard revealed information on both visible and invisible formal and alternative infrastructures, allowing researchers to interact with these infrastructures, while also receiving input from residents. Below we provide an analysis of varied interactions with similar and different water and sanitation infrastructure in the four study communities, from the scorecard. See Figures 2–5 to support this analysis.

Figure 2 shows all the water sources observed in the four study areas. When using the water scorecard, the data collection team suggested that some of these sources were of much higher quality than others. For example, in Z1 private taps were assessed to be relatively higher quality, the water kiosk and standpipe kiosk had

TABLE 8 Water and sanitation options in the four communities and from which method(s) the data were obtained.

Community	Water options		Sanitation options	
	Water	Data source(s)	Sanitation	Data source(s)
Z1	***Formal water options***		Ordinary pit-latrines	Mapping FGD, Transect walk, Weekend observation, FGDs, Water scorecard, KII
	Communal water (kiosk)	Transect walk; mapping FGD; Weekend observations	VIP latrines	Transect walk, Water scorecard
	Boreholes	Mapping FGD; Transect walk; Water score; FGD	Pour flush	Water scorecard
	Private taps	Mapping FGD; KII; Water score	Flush (Indoor and Outdoor)	Water scorecard
	Alternative water options		Piped sewer	FGD, KII
	Stormwater drainage	Mapping FGD, Transect Walk, Weekend observations, FGD, Water score card, KII	Bucket latrines	FGDs, KII
	Shallow wells	Mapping FGD, Transect walk, Weekend observation, FGD, Water score card, KII	"Flying toilets" (opaque beer cartons, plastic bags, and bottles)	Mapping FGD, FGDs, KII
	Scoop well	Transect walk, Water score card		
	Filling station	FGD, IDI-GPS		
	Old council pipe	IDI-GPS		
	Stream	Mapping FGD, Transect walk, Weekend observation, FGD, Water score card, KII		
	Rainwater	Additional observations		
Z2	***Formal water options***		Lusaka Sanitation Program Toilets (LSP)	Transect walk, FGD, Water scorecard, KII
	Potable water from LWSC	Mapping FGD, Transect walk, Weekend observation, FGD, Water scorecard, KII	Pour Flush	FGD, Transect walk, Water scorecard
	Boreholes	Mapping FGD, Transect walk, Weekend observation, FGD, Water score card, KII	Dry and Ventilated pit-latrines	Mapping FGD, Transect walk, FGDs, Water scorecard
	Alternative water options		Communal Toilet (Fee paying)	Mapping FGD, Transect walk, FGDs, Water scorecard, KII
	Households and Churches with private boreholes	Mapping FGD, Transect walk, Weekend observation, FGD, Water scorecard, KII	Flush toilets	Transect walk, FGDs
	Leakages from pipes	FGD, KII		
S3	**Formal water options**		Communal Flush Toilets	Mapping FGD, Transect walk, FGDs, Water scorecard, KII
	Communal water (kiosk) (metered)	Mapping FGD, Transect walk, FGD, Water scorecard, KII	Indoor Flush toilets	Transect walk, FGDs, Mapping FGD
	Communal water standpipes	Mapping FGD, Transect walk, FGD, Water score card, KII	Concrete Flush Toilets (yard)	Transect walk/drive, Mapping FGD, FGD, Water scorecard, KII
	Private concrete taps	Mapping FGD, Transect walk, FGD, Water scorecard, KII	Portable Chemical Toilets (communal)	Transect walk/drive, Mapping FGD, FGD, Water scorecard, KII
	Private shared taps (metered)	Mapping FGD, Transect walk, FGD, Water scorecard, KII	Bucket Toilets	Mapping FGD, FGD, KII
	Private indoor taps (metered)	Mapping FGD, Transect walk, FGD, Water scorecard, KII	Open Defecation	Mapping FGD, FGD, KII
	Alternative water options			
	Illegal pipe connections	Transect walk/drive, Water scorecard, KII		

(Continued)

TABLE 8 (Continued)

Community	Water options		Sanitation options	
	Water	Data source(s)	Sanitation	Data source(s)
S4	**Formal water options**		Indoor flush toilets	Mapping FGD, Transect walk/drive, FGDs, Water scorecard
	Private indoor taps	Transect walk/drive; Mapping FGD; Gender FGD	Concrete flush toilets (yard)	Mapping FGD, Transect walk/drive, FGDs, Water scorecard
	Private Concrete Taps (metered)	Transect walk/drive; Mapping FGD; Water scorecard	Bucket toilets	Mapping FGD, FGD
	Alternative water options			
	Private boreholes	Transect walk/drive		

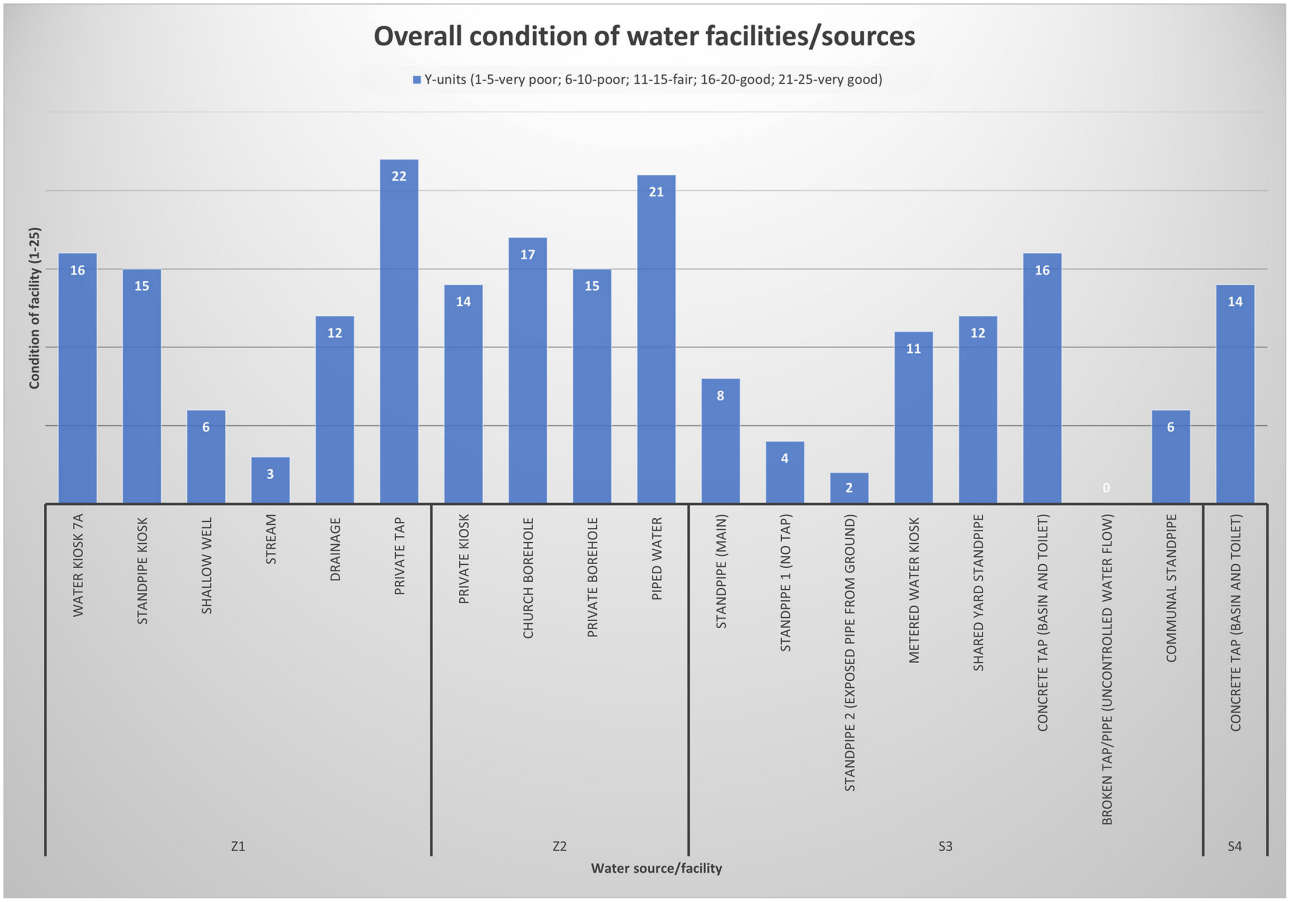

FIGURE 2
Overall condition of water facilities/sources.

relatively moderate quality, whereas the shallow well, local stream, and a drainage culvert were assessed as relatively low quality. Overall, residents with private taps or taps from serviced plots were assessed to have better quality infrastructures than those who collected water from broken communal taps or natural sources like streams and wells. In Figure 4, we illustrate 3 photographs of communal water standpipes/kiosks from piped water in Z1 and S3. The photographs highlight why the same type of infrastructure could be scored variably in different contexts. For example, the standpipe in Z1 scored higher because the surrounding area was visibly cleaner with a more functional structure than the standpipes in S3. Additionally, using the scorecard activity allowed testing for leaks and gathering resident experiences regarding accessibility and networks related to a tap or water collection from neighbors. For instance, shallow wells in Z1 were used for other household activities and not for cooking and drinking and provided a strategy to cushion the cost of water and manage intermittent water supply.

In Figure 3, the range of toilet options observed and assessed using the water and sanitation scorecard, suggested that the Lusaka Sanitation Program Ventilated Improved Pit latrine (LSP

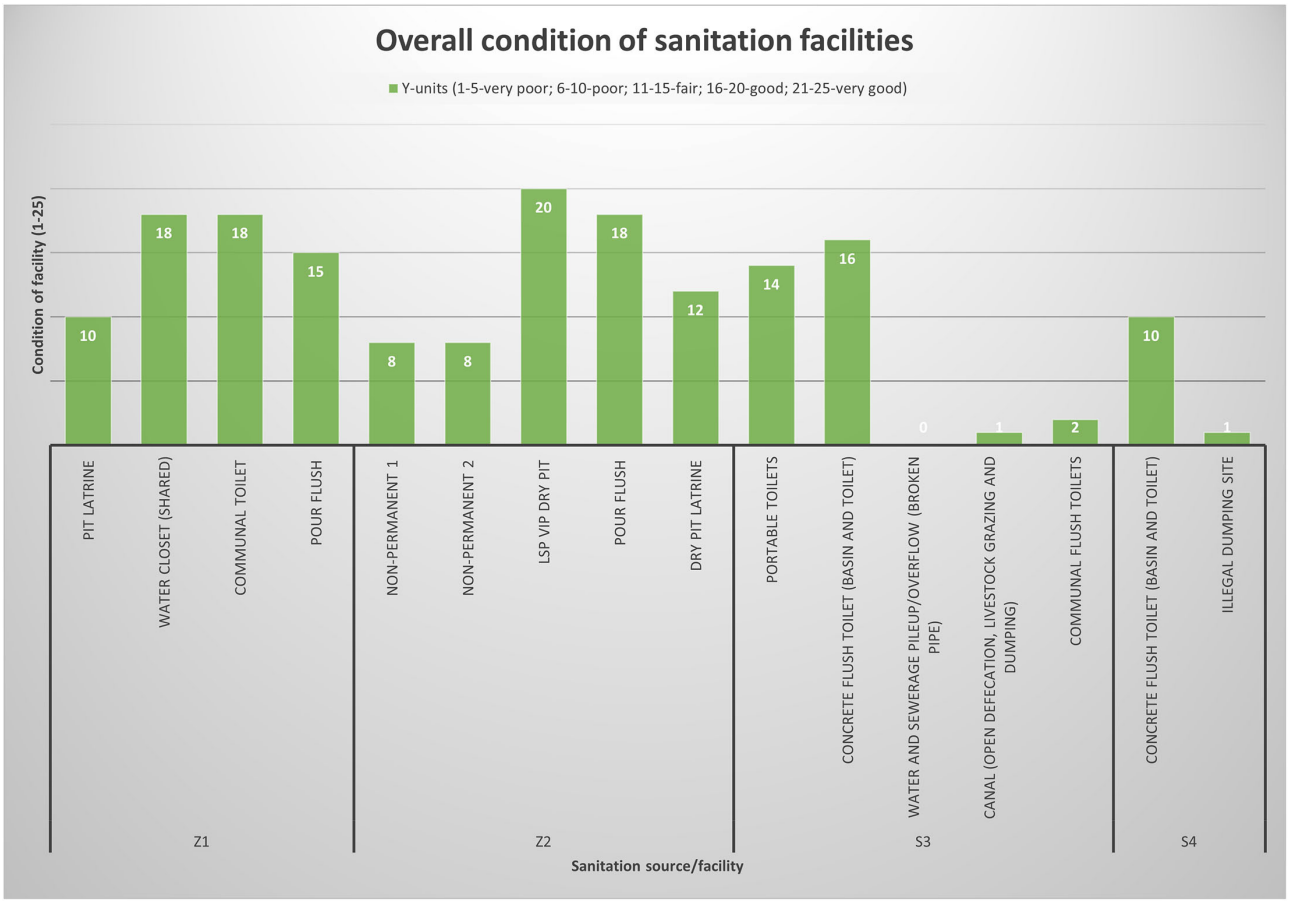

FIGURE 3
Overall condition of sanitation facilities.

FIGURE 4
Conditions of piped water.

FIGURE 5
Conditions of toilets.

VIP dry pit) were of the highest quality, followed by pour flush in Z2, and shared water closet and communal toilet in Z1. Communal flush toilets in S3 were assessed to be of lowest quality due to poor maintenance of the toilets. The photographs in Figure 5 illustrate how portable toilets in S3 were better maintained than the communal flush toilets that were overflowing, and blocked with waste and building rubble. Hence, the photos in Figure 5 provide clarity on why communal flush toilets scored lower. These examples underscore the importance of considering both physical aspects of sanitation infrastructure and residents' experiences and preferences. While flush toilets are often assumed to be the best option, they can be financially challenging to maintain for both residents and local authorities, unlike temporary options like portable toilets or non-flush toilets (dry pits). Shared toilets can lead to breakages, putting financial strain on households to fix them or facing prolonged wait times for authorities to intervene, as observed in a shared yard flush toilet in S4.

Furthermore, indiscriminate waste dumping poses an additional challenge to communal water and sanitation infrastructures, particularly affecting stormwater drains, open spaces, and natural areas. In Figure 4, we observed a communal standpipe in S3 located near a heavily polluted river canal, filled with waste and sewage. Despite the tap's functionality and good water pressure, the obvious unsanitary conditions pose health risks, as confirmed by residents in the area who complain about open defecation practices and the spread of water-borne diseases. The close proximity of waste accumulation and water infrastructure results in unsanitary conditions, as evident in Figure 3, where an illegal dumping site (S4), a canal near communal taps (S3), and sewerage overflow from a broken pipe (S3) scored very poorly in the assessment. This highlights the critical need to address waste management issues to safeguard the health and well-being of communities relying on communal water and sanitation facilities.

3.4. Stakeholder dissemination

Community dialogue meetings were used in all communities to engage with residents, CBEs and local authorities to discuss preliminary findings using participatory approaches. In Zambia, community members agreed that the findings were a true representation of their community's situation. Residents said that although they knew what was happening in their community, the findings including pictures helped them understand the severity of their sanitation situation for example, indiscriminate dumping of solid waste in the stream. Community members also attributed the use of "flying toilets" and using water from shallow wells and the drainage, to financial constraints to construct toilet structures, lack of space, and reducing monetary expenses. The discussion also brought to light that the TWT faced challenges meeting community demands as they only have one reservoir tank.

In South Africa, dialogue meetings revealed new information. This included: how illegal waste dumping has become more pervasive; how higher prices of water have led to more people collecting "free" water from farmlands; how the construction of a major road could have contributed to more drainage issues in the RDP area next to a wetland; and how some political ward councilors/leaders claimed that political rivals sabotaged by dumping waste to weaken the ruling government. Community members mentioned service delivery improvements, such as the government's attempt to enlarge the sewerage pipes to prevent blockages and residents being allocated serviced plots with private water and sanitation facilities. They expressed the need for the government to actively assist them and to implement WASH interventions in their communities.

After community dissemination, findings were shared with national WASH stakeholders, focusing on the need to find sustainable solutions such as administrative spills over areas for unplanned settlements. The stakeholders also discussed how WASH problems were hard to address due to the unplanned

nature of the communities and spoke of the need to find funding for interventions and carry vulnerability assessments accompanied with decentralized innovations.

4. Discussion

We, an interdisciplinary team of social scientists and engineers, conducted a rapid qualitative assessment approach termed a Broad Brush Survey (BBS) over 12–15 days in four sub-Saharan African urban communities in 2021 to depict the local context of water and sanitation infrastructure, services and needs. We conducted this BBS fieldwork during an evolving COVID-19 epidemic and other short (for example national mourning in Zambia), and longer-term challenges (for example, threat of violence in South Africa). The BBS approach involved background research, community entry through political authorities, qualitative data collection in a set sequence of observations, focus group discussions and key informant interviews, and iterative analysis structured by a meta-indicator framework. In a geographically bound community, the meta-indicator framework encompasses: physical features, social organization, social networks and community narratives. Using these meta-indicators systematically illustrated the interface between local context (physical and social) and water and sanitation infrastructure, moving from broader to narrower qualitative observations to build up a layered profile of each community. With systematic data at hand, we could then analyze commonalities and differences across the in-country communities, and across the two countries, for the purpose of water and sanitation infrastructure. The community profiles were rapidly written up using the meta-indicator structure and communicated to the communities and other relevant stakeholders, who were able to use the data for local reflection and/or action linked to water and sanitation. In the discussion, we firstly reflect on the strengths and limitations of the BBS approach applied to water and sanitation infrastructure from an interdisciplinary perspective, and secondly on how findings on water and sanitation contribute to the wider literature in this field.

The BBS approach is not novel for providing a rapid qualitative assessment since the principle of rapid assessment and the use of different combinations of qualitative and participatory methods to this end are well established, and in use for both research and intervention (Vindrola-Padros and Johnson, 2020). With the focus on a geographically bounded community and rooted in sociology and anthropology, the BBS approach is more akin to a rapid ethnographic assessment (Sangaramoorthy and Kroeger, 2020). Within this rapid qualitative assessment field, the BBS makes a clear contribution by using a meta-indicator framework, developed from urban systems theory (Wallman et al., 2011), and a set sequence of qualitative data collection activities and iterative analysis. This combination provides an organizing logic to combining various qualitative data into an overall description of the community, allowing for an understanding of the local context applied to a key research/and or intervention issue, and systematic comparison across communities involved in a study. Ahead of applying the BBS approach to water and sanitation, it has been proven useful to research, community engagement and intervention in six population-based large research studies on Tuberculosis and HIV in SSA (Bond et al., 2019), and continues to be used by interdisciplinary teams in public health population-based research. A BBS manual has recently been developed that should extend the core application of the BBS approach (Bond et al., 2023). Therefore, the application of the BBS approach to water and sanitation infrastructure and with engineers is another test of the usefulness of the approach for applied research and intervention.

This was the first time for engineers to be involved in adjusting and implementing the BBS approach and the first time to our knowledge to apply BBS to water and sanitation infrastructure. The novelty of working with engineering issues was limited to a new topic of application rather than a foundational change in conceptual underpinnings or processes. The water and sanitation literature increasingly acknowledges the importance of transcending disciplinary boundaries, and the potential usefulness of integrating social science with engineering to improve understanding and management of water and sanitation demands by bringing attention and detail to multiple factors that influence equitable water and sanitation access (Lund, 2015; Workman et al., 2021; Tsekleves et al., 2022). Engineers in the research team found that the BBS approach offers valuable insights into both physical and non-physical aspects that are challenging to quantify from a purely technical perspective. Transdisciplinary research faces a pitfall due to differing data collection norms between social sciences and engineering, with engineering emphasizing repeatability, controls, and quantitative results. The meta-indicator and set sequence approach of BBS allows for repeatability and consistency, aligning well with engineering experimental design norms and facilitating cross-comparisons across communities. Additionally, the rapidity of the BBS approach provides detailed insights within the shorter timescale typically required for engineering studies.

Engineers in the team had a particular influence on the addition of a water score card to the BBS data collection activities. The water score card drew on a water and sanitation checklist from the World Health Organization's (WHO) water/sanitary inspection package (WHO, 1997; Roque et al., 2022) (see Supplementary material 1). Research topic specific data collection tools can be integrated into the overall BBS sequence (Bond et al., 2019), and the water and sanitation scorecard is another example of doing this. Although the scorecard has limitations due to subjectivity, it proves valuable in offering an overview of the range of water and sanitation infrastructure within and across communities and the infrastructure accessibility and functionality for those who use these facilities. Utilizing additional tools in BBS enables further analysis to inform the meta-indicators. For instance, in the case of the scorecard, the physical structure, social interactions, user experiences, access and control patterns, and related narratives are observed and documented, and can be utilized in water engineering decision-making.

The involvement of community agency and stakeholders in improving water and sanitation service provision is an established approach, with critical reflections on the use and adjustments of participatory approaches for water services and development (Roque et al., 2022). The water engineers in the research team proved particularly important in organizing interaction

with WASH stakeholders throughout the study. BBS is another pragmatic, flexible approach to add to this toolbox. In each of the communities included in this research we made local-level recommendations for priorities to be addressed in water and sanitation. We presented the community-specific findings in dialogue meetings and shared posters and flyers of the community profile findings with communities and stakeholders. These were displayed locally within certain amenities, and led to some local action including increased awareness of water and sanitation challenges and stakeholder commitment to improve or extend water and sanitation infrastructure.

It should be noted however that this is not a proof demonstrating how findings from the BBS approach have been used to change water and sanitation services. Nor did we directly compare a BBS approach to other rapid approaches to understanding water and sanitation in communities. Extrapolation from our findings should therefore be made cautiously and limited to settings and applications that are similar. Our assessment of the potential feasibility and utility is based on the interdisciplinary project team's opinions. We have substantiated our opinions with examples, but there is an inherent risk of bias since many of us are the developers of the approach.

Other limitations of the BBS approach are that standard qualitative approaches are sacrificed to the interests of a rapid, snap-shot approach. For example, the principles of sampling to saturation and iterative recruitment, data collection, and analysis, are compacted into a limited number of fieldwork days. This means the BBS approach is a more limited, less nuanced understanding that other more in-depth and extensive qualitative approaches. However, we suggest that we have shown that despite this acknowledged limitation, there is still significant utility to the combination of meta-indicator framing with the patchwork of stepwise data collection activities we have outlined. Another limitation is the risk of portraying a designated political and administrative geographical area as a community when it is in reality many communities, as exemplified by S3 and S4.

From the findings we yielded, we could draw comparisons with published literature, which further confirms the usefulness of the BBS approach. The inadequacy of formal water supply systems, toilets and solid waste disposal linked to urban expansion, unplanned settlements and broken infrastructure evident across all four communities in this study resounds with the documented strain on and challenges with formal water and sanitation services observed by other literature (Govender et al., 2011; Amin and Cirolia, 2018; Cinnamon and Noth, 2023). Despite government initiatives in both countries to improve water and sanitation access in urban areas, their implementation has been evaluated as fragmented, lacking community involvement (World Bank, 2016; NDP, 2022). The social organization of water and sanitation infrastructure in the four communities was fragmented and varying, spread across government, NGOs, CBEs, commercial enterprises and faith-based organizations. There were also notable examples of community action in both countries, particularly in response to solid waste management. Further, formal initiatives provided some employment for local residents trained to maintain, safe-guard and often charge for water and sanitation services. Frustrations and feeling neglected in the face of inadequate and demeaning water and sanitations services was palpable and voiced across all four communities, and echoed by other literature (Kennedy-Walker et al., 2015; Ato Armah et al., 2018; Enqvist and Ziervogel, 2019; Rambaree et al., 2019).

Infrastructure development is also juggling need with limited natural resources. Water shortage is a crisis in both cities (Chitonge, 2011; Simukonda et al., 2018; Robins, 2019). Our research, along with other studies (Madonsela et al., 2019), shows that inequitable access to water disproportionately affects lower-income and certain racial groups. For instance, in the Cape Town communities, backyard households with meters may run out of water for flushing or need to inform neighbors when doing laundry. In Lusaka, as noted in other literature (Simukonda et al., 2018; Reaver et al., 2021) residents resort to informal water sources (shallow wells) and rationed water points due to affordability issues.

Formal service planning often overlooks the interaction between place and services, neglecting the importance of informal practices for service delivery (Maryati et al., 2018). Our BBS findings highlight the significance of informal water sources and arrangements for accessing water, toilets and disposing of solid waste. This included the sharing of water and sanitation services, based on economic exchange and/or social networks. For example, households sharing or lacking toilets in the two Lusaka communities is a pattern evident in our own research and other studies (Simukonda, 2015; Tidwell et al., 2018). These informal practices provide options in the absence of formal, accessible, functioning and affordable infrastructure, and also contribute to the informal economy, providing income while compromising safety and health (Maryati et al., 2018; Yang et al., 2018; Nabirye et al., 2023). Our findings highlight the exploitation present in some informal practices, such as varying charges for accessing water. Research in Indonesia suggests that transforming informal systems into formal ones could potentially improve water quality (Maryati et al., 2018). Stakeholders in both cities are aware of informal practices but lack formal recognition and engagement with them. Engendering more infrastructure ownership may help recognize and include informal practices in future planning.

5. Conclusion

In SDG6, water and sanitation is described as ensuring access to water and sanitation for all but implementation is often far behind these ideals (Burton et al., 2021; Sutherland et al., 2021). We believe, whilst acknowledging limitations, that we have demonstrated the potential usefulness of the BBS approach as a rapid, flexible yet rigorous methodology for assessment of context-specific water and sanitation infrastructure challenges in SSA cities, building on a growing body of evidence (Bond et al., 2013, 2019). The appeal of BBS lies in providing a packaged list of activities that make qualitative methods more accessible to non-social science specialists, including engineers, and a framework (the four meta-indicators) that provides the platform for systematic data collection in communities and comparison across communities. Additionally, use of the BBS approach with other disciplines contributed to an applied understanding of the social and environmental factors to consider in planning and implementing water and sanitation programmes. Furthermore, the informal and formal range of water and sanitation infrastructure and community perspectives about

both options emerged through the BBS data. This has revealed the influential role of informal systems in shaping urban landscapes, thereby prompting a re-evaluation of the prevailing perception that formally planned urban areas represent the ultimate goal (Priya et al., 2019). Priorities for future research to further evaluate and develop the BBS approach are (a) wider implementation by users who are first-time adopters of the approach, (b) application across multiple and diverse settings, and (c) evaluating the feasibility of training local community members to lead and implement the approach.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Stellenbosch University Ethics Committee in South Africa (reference Number N20/10/115), University of Zambia Biomedical Research Ethics Committee (Reference Number 1393-2020) in Zambia, the London School of Hygiene and Tropical Medicine (LSHTM) Ethics Committee (Reference number 25789), and the University of Sheffield (Reference number 042825) in the United Kingdom. The studies were conducted in accordance with the local legislation and institutional requirements. Written voluntary informed consent was obtained from all study participants above the age of 18 years. Young people below the age of 18 years gave voluntary informed assent before participating in the study. Additionally, written informed consent was sought from parents or guardians of young people below 18 years old who participated in the study. Additionally, photographs of individuals that were recognizable in the photograph were only taken and stored if written informed consent was obtained. Permission was sought for taking photographs of infrastructure that would identify a place and an explanation was provided that photographs would only be used to provide visual aid to illustrate research findings. Likewise, verbal consent was sought when conducting community observations at places of significance to WASH in the communities.

Author contributions

VB, GH, JS, EM, VS, LV, HJ, and MSimw contributed to conception and design of the study. MN, ZM, JM, TC, VB, MSimu, and EM collected data. MN led on the first draft of the manuscript. MSimu, JM, TC, and VB wrote sections of the manuscript. All authors contributed to the manuscript revision, read, and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frsc.2023.1185747/full#supplementary-material

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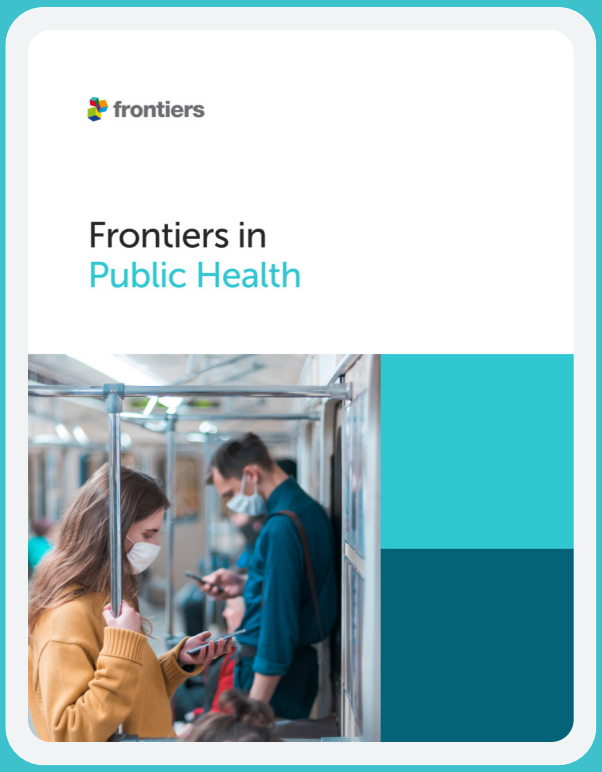

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