



PUBLIC HEALTH *GEOSOCIOLOGY*: A SOCIO-SPATIAL FRAMEWORK FOR UNDERSTANDING STRUCTURAL HEALTH INEQUALITIES

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Abstract

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Both social and spatial processes shape health inequalities, yet sociology and geography have traditionally examined these dimensions separately. This paper advances Public Health Geosociology as an integrative framework that combines the spatial insights of health geography, the structural analysis of medical sociology, and the evaluative tools of public health science. The framework is grounded in three propositions: space is socially produced, society is spatially structured, and health inequality is socio-spatially constructed. It shifts attention from merely identifying where disparities occur to explaining why they persist and how they are reproduced. Central to the framework is the concept of the Geography of Neglect, which explains how the uneven distribution of healthcare infrastructure and public investment systematically disadvantages peripheral populations. Drawing on evidence from Nigeria, sub-Saharan Africa, and comparable contexts, the paper demonstrates how distance, poverty, gender norms, social exclusion, and institutional weakness interact to transform geographic isolation into health exclusion. Methodologically, Public Health Geosociology advocates a triangulated approach that integrates spatial analytics, qualitative social inquiry, and epidemiological evaluation to capture the complex dynamics of health inequality. The framework introduces two key concepts: the Scale-Sociality Nexus, which highlights the limits of local social cohesion under conditions of institutional absence, and the Vaporization of Access, which describes the rapid decline in healthcare accessibility beyond critical distance thresholds. The paper argues that health outcomes in low- and middle-income countries are socio-spatial products of power, policy, and territorial organisation. Achieving Universal Health Coverage requires moving beyond space-blind approaches toward integrated strategies that address spatial, social, and institutional inequalities simultaneously.

Keywords: *Geosociology; Healthcare; Policy; Public Health; Space.*

1.0 INTRODUCTION

Access to healthcare is a fundamental human right, yet significant inequalities persist, particularly in rural areas of low- and middle-income countries (LMICs). These disparities are not accidental but reflect deeper social, spatial, and institutional inequalities embedded within health systems. Understanding why they persist requires moving beyond single-discipline explanations. Health geography demonstrates how distance, terrain, and facility location shape access to care (Ouma et al., 2018), while medical sociology highlights the roles of social class, power, and institutional discrimination in determining health opportunities (Phelan & Link, 2015). Public health science provides the epidemiological tools for measuring health outcomes and evaluating interventions (Krieger, 2011; Diez Roux, 2007).



This disciplinary fragmentation has historical roots in colonial knowledge production, where geography, sociology, and public health evolved along separate intellectual trajectories (Bhambra, 2014; DSA, 2023). Consequently, health geography often maps inequalities without adequately explaining their social origins, medical sociology analyses inequality while paying limited attention to spatial organisation, and public health frequently treats space and society as variables to control rather than structures to theorise (O'Campo & Dunn, 2010; Krieger, 2011). As a result, health inequalities persist despite global commitments to Universal Health Coverage (UHC) and the Sustainable Development Goals (SDGs) (WHO, 2024; World Bank, 2024).

The persistence of these inequalities reflects forms of structural violence embedded within social, political, and economic arrangements that systematically disadvantage particular populations (Galtung, 1969; Farmer et al., 2006). Empirical evidence consistently shows that healthcare resources remain concentrated in urban and economically advantaged regions, while peripheral populations experience shortages of facilities, skilled personnel, and emergency services (Ouma et al., 2018; Bolarinwa et al., 2023). Such patterns exemplify the inverse care law, whereby those with the greatest health needs often have the least access to quality healthcare (Hart, 1971).

In response, this paper advances Public Health Geosociology as an integrative framework that bridges health geography, medical sociology, and public health. Drawing on critical spatial theory (Lefebvre, 1991; Soja, 2010), political economy (Harvey, 2006), medical sociology (Williams & Mohammed, 2013; Phelan & Link, 2015), and spatial epidemiology (Krieger, 2011; Diez Roux, 2007), the framework conceptualises health inequality as a socio-spatial process through which power, place, and institutions interact to shape healthcare access, vulnerability, and health outcomes. Public Health Geosociology can precisely be defined as the study of how spatial organization, social structures, and institutional arrangements interact to shape population health outcomes and produce health inequalities.

The framework rests on three integrated propositions:

1. **Space is socially produced:** Healthcare facility locations, road networks, and service boundaries are not natural or politically neutral. They reflect historical power struggles, budget decisions, and class priorities (Lefebvre, 1991; Harvey, 2006).
2. **Society is spatially structured:** Social class, gender, ethnicity, and power do not float abstractly. They are physically fixed in place, stretched across distance, and constrained by geographic geometry (Massey, 1994; 2005).
3. **Health inequality is socio-spatially fabricated:** It emerges from the interaction of spatial barriers, social determinants, and institutional arrangements, producing patterns that no single discipline can fully explain (Krieger, 2011; Danbuzu et al., 2026).

Research questions:

1. How does the spatial distribution of healthcare facilities interact with social determinants to shape health inequality in LMICs?
2. What social, economic, and cultural barriers mediate access to healthcare in rural settings, and how do these vary across space?
3. How can integrating health geography, medical sociology, and public health science improve our understanding of healthcare utilisation patterns and inform more effective, equitable interventions?



2.0 THEORETICAL FOUNDATIONS

Public Health Geosociology draws on three disciplinary traditions that have historically operated in parallel but rarely in concert. This section integrates their core insights to build a unified theoretical architecture.

2.1 Health Geography: Space, Place, and Therapeutic Landscapes

Health geography examines how spatial arrangements shape health outcomes, moving beyond simple mapping to theorise the relationships between place, power, and wellbeing (Kearns & Moon, 2002; Gesler & Kearns, 2002). Early medical geography focused on disease mapping and environmental determinism locating cholera outbreaks or malaria zones as if illness were purely a function of physical terrain (Meade & Emch, 2010). The contemporary health geography turn, however, recognises that places are not merely containers of disease but active producers of health and illness (Cummins et al., 2007; Andrews et al., 2018).

Therapeutic landscapes theory is particularly relevant. Gesler (1992) and subsequent scholars argue that certain places springs, hospitals, healing centres acquire therapeutic properties through the intersection of physical environment, social meaning, and individual experience. This perspective helps explain why the same clinic may be experienced as welcoming or alienating depending on its location, architecture, and social context (Williams, 1999; Smyth, 2005). In LMICs, however, therapeutic landscapes are often negative spaces places of abandonment where the absence of infrastructure, personnel, and medicines transforms geography into a source of harm rather than healing (Danbuzu et al., 2026).

Health geography also provides the tools for measuring spatial accessibility: GIS-based network analysis, distance-decay modelling, and gravity models that quantify how facility location affects utilisation (Guagliardo, 2004; Ebener et al., 2021). Yet these tools often lack social theory. They can tell us *that* rural populations travel further, but not *why* facilities were placed elsewhere, or *who* can afford to make the journey (Schuurman, 2004; Pearce, 2018).

2.2 Medical Sociology: Power, Class, and Institutional Discrimination

Medical sociology analyses how social structures such as class, race, gender, and institutional power shape health outcomes, healthcare access, and the experience of illness (Cockerham, 2017; NASEM, 2021). Unlike public health's tendency to treat social factors as individual risk factors, medical sociology examines the social production of illness and the political economy of health systems (Waitzkin, 2018; Navarro, 2009).

Fundamental cause theory (Phelan & Link, 2015; Link & Phelan, 1995) argues that social conditions—poverty, education, and social status are *fundamental causes* of disease because they shape access to the flexible resources needed to avoid risks and adopt protective strategies. This theory explains why health inequalities persist even when specific diseases are eliminated: new health threats emerge, but those with greater resources continue to avoid them. In spatial terms, fundamental cause theory implies that geographic location itself is a flexible resource; living near good schools, hospitals, and transport networks provides ongoing health advantages that compound over generations.

Medical sociology also documents institutional discrimination in healthcare delivery. The *weathering hypothesis* (Geronimus, 1992) shows that chronic exposure to social marginalisation accelerates biological ageing among minority populations. Intersectionality theory (Williams & Mohammed, 2013; Crenshaw, 1989) reveals how race, gender, and class interact to produce unique health vulnerabilities that single-axis analyses miss. In rural LMICs, these dynamics mean that poor women from ethnic minorities face triple jeopardy: gender norms restrict mobility, ethnic discrimination limits

facility welcome, and poverty prevents transport payment (Shaikh & Hatcher, 2005; Hamid et al., 2015).

However, medical sociology often treats space as incidental. Class analysis focuses on income gradients without asking *where* the poor live. Race analysis examines discrimination without mapping its territorial concentration. The field needs geography to understand that social disadvantage is always emplaced—rooted in specific locations with particular spatial configurations (Massey, 2005; Cummins et al., 2007).

2.3 Public Health Science: Epidemiology, Systems, and Intervention

Public health science provides the empirical tools for measuring health outcomes, identifying risk factors, and evaluating interventions (Bonita et al., 2006; Tulchinsky & Varavikova, 2014). Spatial epidemiology maps disease patterns, clusters, and transmission routes, using geostatistical methods to identify hotspots and predict spread (Elliott & Wartenberg, 2004; Beale et al., 2008). Health systems research examines how financing, workforce, governance, and service delivery combine to produce health (WHO, 2007; Kruk et al., 2018).

Yet public health science has been criticised for its *lifestyle drift* the tendency to individualise social problems by framing them as matters of personal behaviour rather than structural constraint (Popay et al., 2010). Even when social determinants are acknowledged, they are often treated as variables to control statistically rather than forces to theorise politically (Krieger, 2011; O'Campo & Dunn, 2010). Social epidemiology has attempted to bridge this gap by examining how neighbourhood characteristics poverty rates, social cohesion, built environment affect individual health (Diez Roux & Mair, 2010; Pickett & Pearl, 2001). However, this work often lacks the critical spatial theory to explain *why* neighbourhoods differ or the sociological depth to analyse how power operates within them.

The integration of multilevel modelling in public health examining individual, household, and area effects simultaneously offers methodological promise (Subramanian et al., 2009; Merlo et al., 2005). But without critical theory, such models risk becoming "black boxes" that correlate area deprivation with poor health without explaining the political and economic processes that produce deprivation in the first place (O'Campo & Dunn, 2010; Schuurman, 2004).

2.4 Toward Integration: The Socio-Spatial Production of Health Inequality

Public Health Geosociology integrates these three traditions by recognising that health inequality is produced through the interaction of spatial arrangements, social structures, and institutional power. Health geography provides the tools for measuring spatial accessibility and mapping therapeutic landscapes. Medical sociology provides the theories of power, class, and discrimination that explain why landscapes are arranged as they are. Public health science provides the epidemiological methods for measuring outcomes and evaluating whether interventions work (Table 1).

The integration is not merely additive. Each discipline corrects the others' blind spots:

1. Health geography without medical sociology produces sophisticated maps without explanations.
2. Medical sociology without health geography analyses power without locating it.
3. Public health science without both produces accurate measurements without a theoretical understanding of what is being measured or why it matters.

The concept of *geography of neglect* (Danbuzu et al., 2026) exemplifies this integration. It names the systematic withdrawal of state institutions from peripheral areas as a form of structural violence that transforms physical distance into health exclusion. This is simultaneously:

1. A spatial pattern measurable through GIS and accessibility modelling (health geography).
2. A social relation produced by political and economic power (medical sociology).
3. A health outcome trackable through mortality, morbidity, and utilisation data (public health science).

Table 1: Disciplinary Contributions and Blind Spots

Discipline	Core Contribution	Key Blind Spot	What Public Health Geosociology adds
Health Geography	Spatial accessibility, therapeutic landscapes, GIS mapping	Often lacks social theory of power and inequality	Integrates political economy to explain <i>why</i> spaces are arranged as they are
Medical Sociology	Social determinants, institutional discrimination, fundamental causes	Often treats space as incidental or abstract	Locates social disadvantage in specific territorial configurations
Public Health Science	Epidemiological measurement, intervention evaluation, health systems	Tendency toward lifestyle drift and statistical abstraction	Connects outcome measurement to critical theory of structural production

Source: Authors' Synthesis (2026)

3.0 CONCEPTUAL FRAMEWORK: Public Health Geosociology

Public Health Geosociology integrates spatial, social, and institutional determinants into a unified framework for analysing how health inequality is produced, maintained, and potentially disrupted. Unlike approaches that treat these dimensions as separate variables to be controlled statistically, this framework treats them as mutually constitutive—each dimension actively shapes and is shaped by the others (Krieger, 2011; O'Campo & Dunn, 2010).

3.1 Core Dimensions of Public Health Geosociology

Public Health Geosociology is built on three interrelated dimensions—spatial, social, and institutional—which correspond to the contributions of health geography, medical sociology, and public health science respectively. Together, these dimensions explain how health inequalities are produced, reproduced, and sustained across space.

3.1.1 Spatial Dimension

The spatial dimension draws primarily from health geography and focuses on the geographic distribution of healthcare facilities, transport networks, terrain, and physical infrastructure (Guagliardo, 2004; Ebener et al., 2021). Access to healthcare depends not only on the presence of facilities but also on their accessibility given road quality, travel costs, seasonal barriers, and topographic constraints (Ouma et al., 2018; Bolarinwa et al., 2023). Tools such as Geographic Information Systems (GIS), accessibility modelling, and distance-decay analysis provide powerful methods for measuring these spatial inequalities (Schuurman, 2004; Ngui & Apparicio, 2011). However, spatial arrangements are not neutral. The location of healthcare infrastructure reflects political priorities, economic interests, and historical patterns of investment and neglect



(Harvey, 2006; Boone, 2024). Consequently, spatial inequalities are both geographic and political in nature.

3.1.2 Social Dimension

The social dimension originates from medical sociology and examines how social structures shape individuals' ability to access and utilise healthcare. Factors such as socio-economic status, education, gender norms, ethnicity, social capital, and discrimination influence health opportunities and outcomes (Phelan & Link, 2015; Williams & Mohammed, 2013).

Fundamental Cause Theory argues that social resources function as flexible assets that enable individuals to overcome barriers to healthcare access (Link & Phelan, 1995; Phelan et al., 2010). Wealth, education, and social networks increase the capacity to navigate referral systems, afford transportation, and secure quality care. Conversely, poverty, social exclusion, and discrimination limit healthcare utilisation even where services are geographically available (Shaikh & Hatcher, 2005; Jacobs & D'Exelle, 2011). These social inequalities frequently overlap with spatial inequalities, reinforcing patterns of disadvantage (Cummins et al., 2007; Pearce, 2018).

3.1.3 Institutional Dimension

The institutional dimension derives from public health science and focuses on the governance structures, policies, financing systems, workforce distribution, and service delivery arrangements that shape health outcomes (WHO, 2007; Kruk et al., 2018). Institutions determine how resources are allocated, which populations are prioritised, and how healthcare services are organised across territories.

Health systems frameworks identify six key building blocks—service delivery, workforce, information systems, medical products, financing, and governance—as essential components of effective healthcare provision (WHO, 2007). Yet institutional arrangements often reproduce inequalities by concentrating resources in politically influential regions while neglecting peripheral populations (Boone, 2024; Danbuzu et al., 2026). Medical sociology further demonstrates that institutions are embedded in relations of power, professional dominance, and social exclusion rather than operating as neutral bureaucratic systems (Freidson, 1970; Navarro, 2009).

3.1.4 Integrating the Three Dimensions

Public Health Geosociology argues that no single dimension can adequately explain health inequality. Spatial factors determine where services are located, social factors influence who can access them, and institutional factors shape how resources are distributed and governed. Health inequalities emerge through the interaction of these dimensions rather than from any one factor in isolation. Consequently, understanding healthcare access requires an integrated socio-spatial perspective capable of linking geography, society, and institutions within a single analytical framework (Table 2).

Table 2 compares how four analytical approaches conceptualise, measure, and address health inequality. Health Geography excels at spatial precision but lacks a social theory of power. Medical Sociology provides a deep analysis of class, gender, and institutional discrimination, but is often spatially blind. Public Health Science delivers rigorous outcome measurement and intervention evaluation, but tends toward *lifestyle drift* that individualises structural problems.

Table 2: Comparative Perspectives on Health Inequality

Dimension	Health Geography	Medical Sociology	Public Health Science	Public Health Geosociology
Primary Focus	Where facilities are located and how reachable they are	Who is disadvantaged by social structures and why	What interventions work and how to deliver them at scale	How spatial layout, social power, and institutional rules interact to produce health gaps
Core Question	What is the distance to the nearest clinic?	What social class, gender, or ethnicity predicts poor health?	How can we reduce disease burden and improve population health?	How does the political and geometric organisation of space actively create health marginalisation?
Theoretical Foundation	Spatial interaction theory; distance-decay; accessibility modelling (Hansen, 1959; Guagliardo, 2004)	Structural violence; fundamental cause theory; intersectionality; institutional discrimination (Galtung, 1969; Link & Phelan, 1995; Crenshaw, 1989)	Epidemiological transition; health systems framework; evidence-based medicine (Omran, 1971; WHO, 2007)	Critical spatial theory (Lefebvre, 1991; Soja, 2010); political economy (Harvey, 2006); structural violence (Farmer et al., 2006); fundamental cause theory (Link & Phelan, 1995)
Key Method	GIS mapping; network analysis; 2SFCA; gravity models; spatial autocorrelation (Moran's I)	In-depth interviews; ethnography; focus groups; narrative analysis; participatory methods	Randomised controlled trials; cohort studies; multilevel modelling; health systems assessment; DALY measurement	Triangulated synthesis: GIS + spatial ethnography + multilevel modelling + participatory counter-cartography + health systems assessment
Spatial Analysis	Precise measurement of travel time, distance, facility density, terrain barriers	Limited: treats space as incidental or abstract; rarely maps disadvantage	Moderate: spatial epidemiology maps disease clusters; often treats space as confounder	Full: maps accessibility, identifies hotspots, models distance-decay, reveals institutional deserts
Social Analysis	Limited: treats users as homogeneous; ignores who can afford to travel	Deep analysis of class, gender, race, power, and institutional discrimination	Moderate: social determinants acknowledged but often reduced to individual risk factors (<i>lifestyle drift</i>)	Full: analyses how class, gender, ethnicity, and power mediate spatial access; intersectional analysis
Health Outcome	Access disparities (travel time, distance, coverage gaps)	Social inequality (income, education, occupation gradients in mortality/morbidity)	Disease incidence, prevalence, mortality, intervention coverage, cost-effectiveness	Structural health inequality: mortality, morbidity, utilisation, trust deficits produced by socio-spatial interaction
Policy Implication	Optimise facility location; improve transport infrastructure	Reduce social exclusion; address discrimination; strengthen patient rights	Scale proven interventions; strengthen health systems; achieve UHC and SDGs	Restructure spatial, social, and institutional arrangements simultaneously; adopt <i>Geosociology of Practice</i>
Limitation	Often ignores why facilities are located where they are; lacks theory of power and inequality	Often ignores where disadvantage concentrates geographically; spatially blind	Tendency toward <i>lifestyle drift</i> (individualising structural problems); often lacks critical theory of why inequalities persist	Resource-intensive; requires interdisciplinary teams; politically challenging (exposes power structures)

Source: Authors' Synthesis (2026)



Public Health Geosociology integrates all three, correcting each discipline's blind spot while acknowledging its own resource and political demands. The table demonstrates that no single discipline can fully explain or address health inequality; integration is not additive but transformative.

3.2 Interaction Mechanism: The Socio-Spatial Production of Health Inequality

Health inequality emerges from the interaction of these three dimensions. This interaction is not additive but multiplicative each dimension amplifies the others (Krieger, 2011; O'Campo & Dunn, 2010).

Spatial barriers raise the cost and difficulty of accessing care. Distance increases travel time, transport expenses, and opportunity costs (lost wages, childcare needs). Seasonal flooding or poor roads can render facilities unreachable for months (Ouma et al., 2018; Bolarinwa et al., 2023).

Social factors determine who can afford to overcome these barriers. Gender norms may prohibit women from travelling alone. Ethnic discrimination may mean staff refuse service or provide substandard care. Poverty may make transport costs prohibitive (Shaikh & Hatcher, 2005; Hamid et al., 2015). Medical sociology's intersectionality theory (Crenshaw, 1989; Williams & Mohammed, 2013) is essential here: a poor rural woman from a minority ethnic group faces not simply three separate disadvantages but a unique configuration of vulnerability produced by their interaction.

Institutional factors set the rules that create and sustain these barriers. Budget formulas that allocate per capita rather than by need ignore distance-decay effects. Workforce policies that fail to incentivise rural posting leave peripheral areas understaffed. Governance structures that are unresponsive to marginalised voices perpetuate neglect (Kruk et al., 2018; Gilson, 2003; Danbuzu et al., 2026).

The result is a cyclical, self-reinforcing system of health inequality:

1. Spatial isolation reduces service use.
2. Reduced use lowers health outcomes.
3. Poor health weakens economic productivity and political voice.
4. Weakened voice justifies further institutional neglect.
5. Further neglect deepens spatial marginalization.
6. The cycle repeats across generations.

Public Health Geosociology names this cycle the *geography of neglect* a pattern where the systematic withdrawal of state presence from peripheral areas operates as structural violence that transforms physical distance into health exclusion (Danbuzu et al., 2026; Farmer et al., 2006).

3.3 The Vaporization of Access: A Non-Linear Distance-Decay Function

Near the institutional core, major cities and administrative centres healthcare rights are relatively realisable. Facilities are dense, transport is available, and the social bond between citizen and state is reinforced by visible institutional presence (Lefebvre, 1991; Soja, 2010).

As populations move into peripheral areas, access does not decline gradually. It hits a critical threshold and vaporizes (Danbuzu et al., 2026). Beyond this point, the compounding effects of distance, cost, and isolation transform statutory rights into practical impossibilities. This non-linear distance-decay means that a clinic five kilometres away may be reachable, while one fifteen kilometres away may as well not exist for poor rural households (Guagliardo, 2004; McGrail & Humphreys, 2009).

Health geography provides the mathematical modelling for this phenomenon—generalised logistic functions, gravity models, and two-step floating catchment areas (Ngui & Apparicio, 2011; Luo & Qi, 2009). Medical sociology explains *why* the threshold exists: it is not a natural feature of distance but a political artefact produced by budget decisions that ignore peripheral need (Harvey, 2006; Phelan & Link, 2015). Public health science then measures the health consequences: higher maternal mortality, lower vaccination coverage, and untreated chronic conditions (Krieger, 2011; NASEM, 2021).

Public Health Geosociology seeks to explain how spatial arrangements, social structures, and institutional power interact to produce health inequality. The Vaporisation of Access concept directly addresses this objective by explaining how healthcare access does not decline linearly with distance but collapses once critical socio-spatial thresholds are crossed.

In practical terms, a clinic located 5 km away may remain accessible, but at 20 km, when combined with poverty, poor roads, gender restrictions, lack of transport, and weak health infrastructure, access effectively disappears. The right to healthcare may still exist legally, but it becomes functionally unrealizable. This makes the concept valuable because it links Health Geography (distance-decay, accessibility, and spatial barriers), Medical Sociology (poverty, gender, power, social and exclusion) and Public Health (utilisation rates, morbidity, mortality, and health-system performance).

3.4 The Scale–Sociality Nexus

A critical insight from integrating the three disciplines is the Scale–Sociality Nexus (Danbuzu et al., 2026). At the micro-scale (villages, neighbourhoods), physical proximity often generates dense social cohesion, mutual aid, and informal health practices. These therapeutic communities can provide substantial support—traditional birth attendants, herbal remedies, and emotional care (Gesler, 1992; Williams, 1999).

However, at the macro-scale, these same cohesive communities are often entirely marginalised by national health systems. Their dense local sociality cannot compensate for absolute institutional absence. Rural villages may have exceptional mutual aid yet lack antibiotics, emergency surgery, or skilled birth attendance (Kruk et al., 2009; Ouma et al., 2018).

Medical sociology reveals why this paradox persists: macro-scale institutions are designed by and for urban elites who neither see nor value peripheral sociality (Phelan & Link, 2015; Navarro, 2009). Health geography maps the resulting institutional deserts. Public health science measures the mortality consequences. The Scale–Sociality Nexus thus exposes a central contradiction of global health: local social capital is routinely overwhelmed by macro-institutional absence.

The Public Health Model illustrates how spatial inequality, social disadvantage, and institutional neglect interact to produce accessibility barriers, which shape utilisation patterns and ultimately generate health inequality. This process is cyclical: poor health outcomes weaken community capacity to demand resources, reinforcing neglect over time. The vaporisation of access occurs at the critical threshold where spatial, social, and institutional barriers compound beyond navigability (Figure 1 / Table 3).

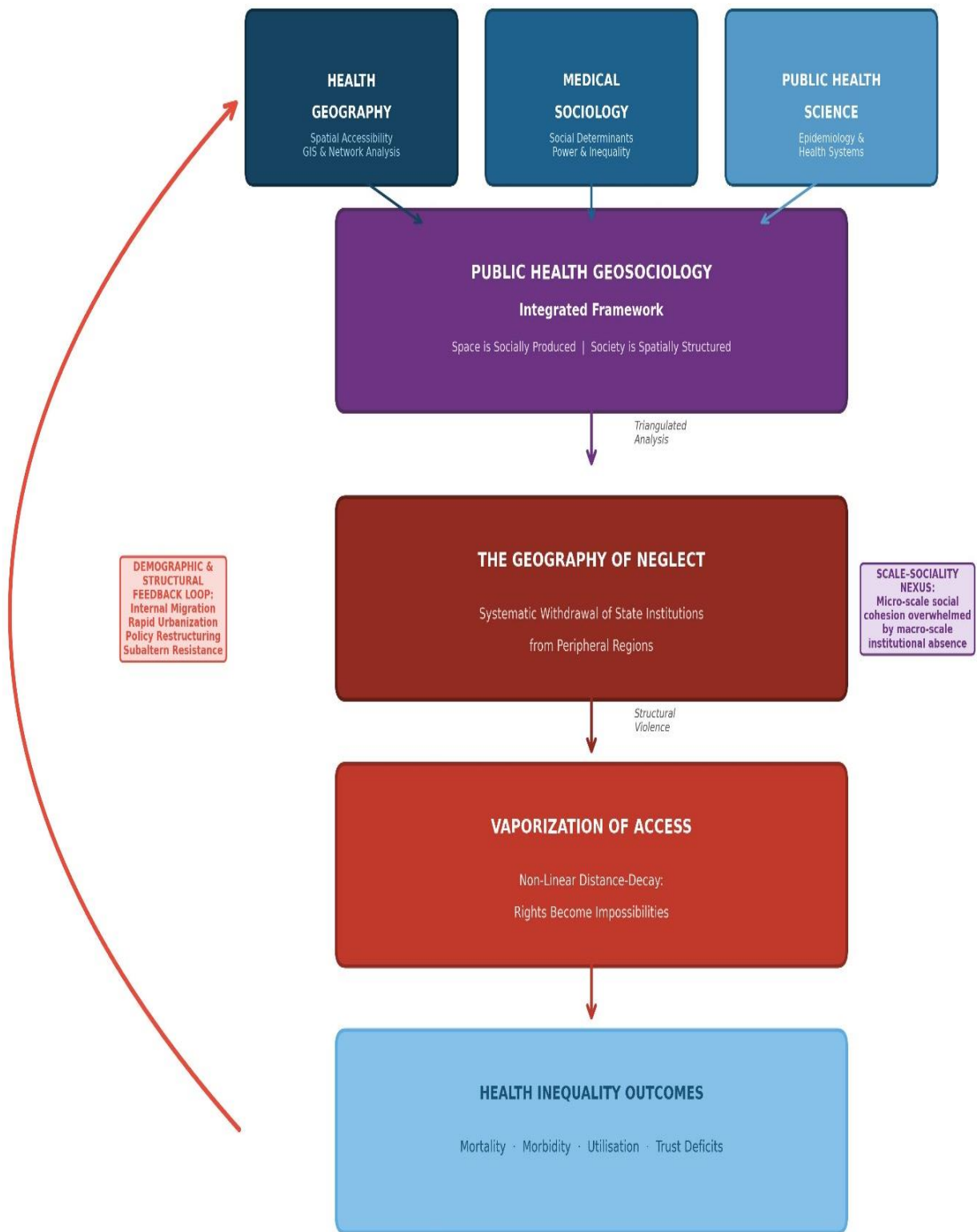


Figure 1: Public Health Geosociology Model

Table 3: Comparative Perspectives on Health Inequality

Dimension	Health Geography	Medical Sociology	Public Health Science	Public Health Geosociology
Primary focus	Where facilities are located	Who is disadvantaged socially	What interventions work	How spatial layout, social power, and institutional rules interact to produce health gaps
Key question	What is the distance to the nearest clinic?	What social class or identity predicts poor health?	How can we reduce disease burden?	How does the political and geometric organisation of space actively create health marginalisation?
Method	GIS, mapping, network analysis	Surveys, interviews, social theory	Randomised trials, epidemiological modelling, health systems evaluation	Integrated modelling combining spatial metrics, qualitative social analysis, and outcome measurement
Outcome measured	Access disparities (travel time, distance)	Social inequality (income, education gradients)	Disease incidence, mortality, intervention coverage	Structural health inequality produced by the interaction of space, society, and institutions
Limitation	Often ignores why facilities are located where they are	Often ignores where disadvantage concentrates geographically	Often treats social and spatial factors as confounders to control	Addresses all three gaps by integrating spatial measurement, social theory, and epidemiological evaluation
Policy implication	Locate facilities optimally	Reduce social exclusion	Deliver effective interventions	Restructure spatial, social, and institutional arrangements simultaneously

Source: Authors' synthesis (2026)

4.0 METHODS: A Triangulated Socio-Spatial Approach

Public Health Geosciology demands methodological approaches that can capture the interaction of spatial, social, and institutional dimensions. This study adopts a triangulated mixed-methods design that integrates quantitative spatial analytics, qualitative social inquiry, and epidemiological outcome measurement. This integration reflects the framework's core premise: health inequality cannot be fully understood by any single method or discipline.

4.1 Quantitative Spatial Methods (Health Geography)

Geographic Information Systems (GIS) form the backbone of spatial analysis. GIS enables the mapping of healthcare facility locations, road networks, population distribution, and terrain characteristics (Schuurman, 2004; Ngui & Apparicio, 2011). Network analysis calculates actual travel routes rather than straight-line distances, accounting for road quality, topography, and seasonal barriers (Ouma et al., 2018; Ebener et al., 2021).



Accessibility indices quantify spatial inequality. The two-step floating catchment area (2SFCA) method measures the ratio of supply (facilities, beds, physicians) to demand (population) within a given travel threshold, capturing both spatial separation and competition for scarce resources (Luo & Qi, 2009; McGrail & Humphreys, 2009). Gravity models extend this by incorporating distance-decay functions that reflect how utilisation drops non-linearly with increasing distance (Guagliardo, 2004; Ngui & Apparicio, 2011).

Spatial autocorrelation (Moran's I, Geary's c) tests whether health outcomes, facility distribution, or poverty cluster in space or appear randomly (Anselin, 1995; Getis & Ord, 1992). This identifies "hotspots of neglect"—contiguous areas where low health outcomes, missing infrastructure, and social deprivation reinforce each other (Danbuzu et al., 2026).

Spatial regression models (spatial lag, spatial error, geographically weighted regression) account for spatial dependency the tendency for nearby areas to have similar outcomes (Anselin, 2002; Fotheringham et al., 2002). These models calculate how distance from the institutional core independently shapes health outcomes, controlling for individual-level social and economic factors.

However, health geography's quantitative tools have limitations. They can map patterns precisely but often cannot explain *why* patterns exist or *how* they are experienced (Schuurman, 2004; Pearce, 2018). This requires qualitative social inquiry.

4.2 Qualitative Social Methods (Medical Sociology)

Spatial ethnography immerses researchers in the everyday spaces of health and illness, observing how social relations, power dynamics, and cultural practices manifest in physical settings (Cummins et al., 2007; Lefebvre, 1991). In rural LMICs, this means observing how households organise transport for emergencies, how gender norms constrain women's facility access, how ethnic minorities experience discrimination at clinics, and how informal healing practices fill institutional gaps (Shaikh & Hatcher, 2005; Hamid et al., 2015).

In-depth interviews capture live experiences of navigating health systems. Medical sociology's illness narrative approach (Kleinman, 1988; Frank, 1995) elicits how individuals make sense of symptoms, seek care, and respond to treatment within specific social and spatial contexts. These narratives reveal the *work* of accessing care—the negotiations, sacrifices, and strategising required to overcome barriers (Peters et al., 2008; Jacobs & D'Exelle, 2011).

Focus group discussions explore collective understandings of health, place, and institutional trust. They reveal how community members share information about facility quality, how stigma operates territorially, and how local social networks mediate access (Gilson, 2003; Shaikh & Hatcher, 2005).

Participatory mapping empowers communities to document their own health landscapes—marking facilities, transport routes, hazardous zones, and healing sites. This counter-cartography challenges official maps that often ignore informal settlements, seasonal routes, and community-defined boundaries (Chambers, 2006; Elwood, 2006).

However, qualitative methods alone cannot establish generalisable patterns or measure outcome differentials. This requires epidemiological integration.

4.3 Epidemiological Methods (Public Health Science)

Cross-sectional and cohort studies measure health outcomes (mortality, morbidity, utilisation, satisfaction) across spatially defined populations, enabling the quantification of gradients by distance, urban/rural residence, and neighbourhood deprivation (Diez Roux, 2007; Krieger, 2011).

Multilevel modelling disentangles individual, household, and area effects on health (Subramanian et al., 2009; Merlo et al., 2005). This is essential for Public Health Geosociology because it can test whether spatial context (e.g., living in an institutional desert) has independent effects on health after controlling for individual social and economic characteristics.

Health systems assessment evaluates the six WHO building blocks—service delivery, health workforce, information, medical products, financing, and leadership/governance—in spatially disaggregated terms (WHO, 2007; Kruk et al., 2018). This reveals *where* systems are weak and *why* whether due to workforce shortages, stockouts, poor supervision, or budget leakage.

Intervention evaluation assesses whether spatially targeted programs (mobile clinics, community health workers, transport vouchers) improve outcomes and reduce inequalities (Scott et al., 2024; Kruk et al., 2018). Rigorous evaluation preferably cluster-randomised designs—can establish causality and cost-effectiveness.

However, epidemiological methods risk *lifestyle drift* reducing structural problems to individual risk factors (Popay et al., 2010). Without critical spatial theory, epidemiologists may find that "rural residence predicts mortality" without asking *why* rurality is hazardous. Without medical sociology, they may control for "education" without theorising how education operates as a flexible resource. The integration of all three disciplines prevents this reductionism.

4.4 Mixed-Methods Integration

The core methodological innovation of Public Health Geosociology is systematic synthesis across methods and scales (Figure 4). This occurs at multiple points:

1. **Sequential integration:** Quantitative spatial analysis identifies *hotspots of neglect* where accessibility is lowest and outcomes poorest. Qualitative inquiry then explores *how* residents of these hotspots experience barriers and navigate care. Epidemiological assessment measures whether interventions improve outcomes.
2. **Concurrent integration:** Spatial mapping, social surveys, and health outcome measurement occur simultaneously in the same populations, enabling direct comparison of spatial, social, and health data.
3. **Transformative integration:** Findings from one method inform the design of others. Qualitative discovery of unmapped seasonal routes leads to revised GIS networks. Spatial identification of unexpected clusters prompts new interview topics. Outcome data reveal which qualitative themes predict mortality.
4. **Scale-crossing integration:** Micro-level ethnography (household negotiations), meso-level surveys (community health profiles), and macro-level spatial analysis (regional accessibility maps) are connected through explicit theoretical frameworks that specify how processes at one scale shape those at others (Cummins et al., 2007; O'Campo & Dunn, 2010).

4.5 Application to this Study

This paper applies the triangulated approach through a narrative literature review that synthesises existing evidence across disciplines, methods, and contexts.

1. **Search strategy:** Databases included PubMed, Scopus, Web of Science, Google Scholar, ScienceDirect, and Sociological Abstracts. Search strings combined spatial, social, and health terms with Boolean operators: ("spatial" OR "geographic" OR "distance" OR "accessibility") AND ("health inequality" OR "healthcare access" OR "health outcome") AND ("social determinant" OR "structural

violence" OR "institutional") AND ("LMIC" OR "developing country" OR "Sub-Saharan Africa" OR "South Asia" OR "rural"). Hand-searching of reference lists and citation tracking identified additional sources.

2. **Selection criteria:** Inclusion: peer-reviewed empirical studies, theoretical frameworks, or major policy reports (2000–2025) with explicit attention to spatial and social dimensions of health in LMICs. Exclusion: studies focused exclusively on high-income countries; clinical trials without social or spatial analysis; non-English sources (acknowledging language bias).

3. **Screening:** Approximately 65 sources were screened; 45 were selected for full synthesis based on quality, relevance, and theoretical contribution across health geography, medical sociology, and public health science.

4. **Analysis:** Thematic synthesis (Braun & Clarke, 2006) organised evidence around: (1) spatial inequality and accessibility; (2) social barriers and mediation; (3) institutional arrangements and health systems; (4) integrated socio-spatial outcomes; (5) intervention effectiveness.

Table 4: Methods Integration Matrix

Research Questions	Health Geography Methods	Medical Sociology Methods	Public Health Science Methods	Integrated Output
Where are facilities located and who can reach them?	GIS mapping, network analysis, 2SFCA	—	—	Accessibility maps with supply-demand ratios
Why are facilities located where they are?	—	Document analysis, elite interviews, and historical institutionalism	Health systems assessment	Political economy of health infrastructure
What barriers do people face?	—	Spatial ethnography, illness narratives, focus groups	Cross-sectional surveys	Typology of barriers (spatial, economic, cultural, institutional)
How do barriers interact?	Spatial regression	Intersectional analysis, qualitative comparative analysis	Multilevel modelling	Model of socio-spatial interaction effects
What are the health consequences?	Spatial epidemiology, hotspot mapping	—	Cohort studies, mortality surveillance, DALY measurement	Geo-referenced health outcome gradients
Do interventions work?	Pre-post spatial analysis	Process evaluation, implementation science	Cluster-randomised trials, cost-effectiveness analysis	Integrated impact assessment

Source: Authors' synthesis (2026)



5.0 DISCUSSIONS: The Socio-Spatial Production of Rural Health Inequality

This section synthesises evidence across the three disciplinary lenses to demonstrate how health inequality is produced through the interaction of spatial, social, and institutional factors. Rather than presenting separate disciplinary findings, it organises evidence around the integrated mechanisms of the Public Health Geosociology framework.

5.1 Spatial Patterning: The Uneven Geography of Health Infrastructure

Health geography consistently documents the urban concentration of healthcare resources in LMICs. In sub-Saharan Africa, 50% of the population lives more than 5 km from the nearest hospital, with rural areas facing extreme deficits in facility density, skilled workforce, and emergency transport (Ouma et al., 2018; Bolarinwa et al., 2023). In Nigeria's Kano State, the Bichi Local Government Area has only 12 health facilities serving a population of over 300,000, with average travel times exceeding 90 minutes during the rainy season (Abdulkarim et al., 2017).

GIS-based accessibility modelling reveals that this pattern is not random. Distance-decay effects are steep and non-linear: utilisation drops sharply beyond 5 km for primary care and 10 km for emergency obstetric services (Guagliardo, 2004; McGrail & Humphreys, 2009). The 2SFCA method shows that rural supply-demand ratios for physicians are often 1:50,000 compared to urban ratios of 1:5,000 (Ebener et al., 2021). Gravity models confirm that the *friction of distance* combining actual travel time, transport cost, and terrain difficulty operates as an active barrier that structures health access (Ngui & Apparicio, 2011).

However, health geography's maps require sociological interpretation. Why do facilities cluster in cities? Medical sociology points to structural violence embedded in budget processes: urban elites control health ministries, electoral calculations favour visible urban projects, and rural populations lack political voice to demand resources (Phelan & Link, 2015; Boone, 2024). Public health science then measures the mortality consequences: maternal mortality ratios in rural Nigeria are 3–4 times higher than in Lagos, with most deaths occurring during transport to facilities (WHO, 2022; Kruk et al., 2018).

5.2 Social Mediation: Who Can Overcome Spatial Barriers?

Spatial barriers do not affect everyone equally. Medical sociology's fundamental cause theory predicts that those with greater social resources can better navigate geographic obstacles (Link & Phelan, 1995; Phelan et al., 2010). Evidence confirms this:

Economic resources determine transport mode. Wealthy households hire motorcycles or cars; poor households walk or rely on borrowed transport (Jacobs & D'Exelle, 2011; Wagstaff, 2010). In rural Tanzania, transport costs consume 15–25% of monthly household income for a single clinic visit, forcing trade-offs between healthcare and food (Peters et al., 2008).

Gender norms constrain mobility. In Northern Nigeria, *purdah* practices restrict women's unsupervised travel, meaning that maternal health emergencies require male accompaniment—which may be unavailable, unwilling, or delayed (Shaikh & Hatcher, 2005; Hamid et al., 2015). Health geography's accessibility maps thus overestimate women's actual access unless gendered mobility is incorporated (Ouma et al., 2018).

Ethnic discrimination shapes facility experience. Minority ethnic groups report longer waiting times, disrespectful treatment, and lower quality care at the same facilities (Williams & Mohammed, 2013; Das & Hammer, 2007). In India's Delhi slums, Muslim patients receive less thorough examinations than Hindu patients at the same clinics (Das & Hammer, 2007). This institutional discrimination

transforms spatial proximity into social distance: the facility is nearby but effectively unreachable due to anticipated mistreatment.

Education operates as a flexible resource that enables navigation of complex referral systems, understanding of treatment protocols, and assertiveness in demanding care (Phelan & Link, 2015). Yet education is itself spatially distributed: rural areas have fewer schools, lower quality teaching, and higher dropout rates, compounding health disadvantage across generations (World Bank, 2023).

Public health science measures these interactions through multilevel models. In South Africa, individual poverty and area deprivation interact to produce tuberculosis mortality rates 8 times higher than either factor alone (Barnighausen et al., 2014). The interaction effect is greater than the sum of individual and area effects, confirming that health inequality is socio-spatially produced, not simply socially or spatially determined.

5.3 Institutional Arrangements: The Health System as Spatial Regime

Public health science's health systems framework reveals how institutional rules create and sustain spatial inequality (WHO, 2007; Kruk et al., 2018). Six building blocks are all spatially biased:

Service delivery concentrates specialised care in cities. Tertiary hospitals with surgery, oncology, and advanced diagnostics are overwhelmingly urban, while rural facilities offer only basic outpatient services (Kruk et al., 2018; Ouma et al., 2018).

Health workforce distribution follows urban preference. Medical graduates refuse rural posting due to poor infrastructure, isolation, and career stagnation (Kruk et al., 2018; WHO, 2024). Incentive schemes higher salaries, faster promotion—have limited success because they fail to address the social and spatial deprivation of rural life (Kruk et al., 2018).

Information systems rarely capture sub-district variation. National health management information systems aggregate data to district or regional levels, masking local *hotspots of neglect* where facilities, personnel, and medicines are simultaneously absent (Danbuzu et al., 2026).

Medical products supply chains favour accessible locations. Cold chains for vaccines, secure storage for narcotics, and reliable transport for emergency stocks all work better in urban settings with electricity and all-weather roads (Kruk et al., 2018).

Financing mechanisms often deepen inequality. User fees, introduced under structural adjustment, hit rural poor households hardest (Jacobs & D'Exelle, 2011; Wagstaff, 2010). Fee abolition improves utilisation but without compensatory financing, rural facilities lose resources and quality declines (Kruk et al., 2018).

Leadership and governance are captured by urban elites. Health ministry officials, parliamentarians, and media are city-based, making rural suffering invisible in policy deliberations (Boone, 2024; Phelan & Link, 2015). Decentralisation to local governments has mixed results: some local authorities prioritise rural investment, others reproduce urban bias (Kruk et al., 2018).

Medical sociology reveals that these institutional arrangements are not neutral technical failures but political choices that protect urban privilege (Navarro, 2009; Waitzkin, 2018). Health geography maps its spatial expression. Public health science measures their health consequences. The integration shows that the health system is a spatial regime—a set of rules that systematically distributes life chances across territory.



5.4 The Vaporization of Access: When Rights Become Impossibilities

Near the institutional core, healthcare rights are relatively realisable. A woman in Lagos with pregnancy complications can reach a hospital within 30 minutes, with multiple transport options, and reasonable expectation of quality care (Abdulkarim et al., 2017; Ouma et al., 2018).

As distance increases, the compounding effect of spatial, social, and institutional barriers produces vaporization. In rural Northern Nigeria, the same woman faces:

1. **Spatial:** 50+ km to nearest hospital, dirt roads are impassable in rains, no emergency transport.
2. **Social:** Purdah restrictions on travel, poverty preventing hired transport, low education limiting navigation of referral system.
3. **Institutional:** No skilled birth attendant at local clinic, no ambulance service, no phone network to call for help.

The result is a practical impossibility. The legal right to emergency obstetric care exists on paper but is vaporised by the geometry of uninvested space (Danbuzu et al., 2026). Maternal mortality in this context is not a medical failure but a socio-spatial fabrication—produced by the interaction of distance, gender, poverty, and institutional neglect (Kruk et al., 2018; Farmer et al., 2006).

Public health science quantifies this vaporisation. In Ethiopia, skilled birth attendance drops from 80% within 5 km of a hospital to 15% beyond 25 km (Kruk et al., 2018). In Nigeria, facility delivery rates are 90% in urban Lagos and 12% in rural Sokoto (WHO, 2022). The drop is not linear but threshold-based: beyond a critical distance, utilisation collapses.

Health geography models this through generalised logistic functions that capture the sharp transition from accessible to inaccessible (Danbuzu et al., 2026). Medical sociology explains that the threshold is politically constructed: it reflects budget decisions that ignore peripheral need. Public health science measures the mortality: each 10 km increase in distance to emergency care raises maternal mortality risk by 30–50% (Kruk et al., 2018; Ouma et al., 2018).

5.5 The Scale–Sociality Nexus: When Local Solidarity Meets Macro Abandonment

The Scale–Sociality Nexus reveals a central paradox of rural health (Danbuzu et al., 2026). At the micro-scale, rural communities often exhibit dense social cohesion, mutual aid, and informal health practices. Traditional birth attendants, herbal healers, and neighbourly care networks provide substantial support (Gesler, 1992; Williams, 1999).

However, at the macro-scale, these same communities are institutionally abandoned. Their dense local sociality cannot compensate for the absence of antibiotics, blood transfusions, caesarean sections, or skilled surgical intervention. A traditional healer can comfort but cannot stop postpartum haemorrhage. Community solidarity can raise funds but cannot buy what does not exist.

Medical sociology explains why this paradox persists: macro-scale institutions are designed by and for urban elites who neither see nor value peripheral sociality (Phelan & Link, 2015; Navarro, 2009). Health geography maps the resulting institutional deserts. Public health science measures the mortality consequences: 60% of maternal deaths in rural sub-Saharan Africa occur in communities with no skilled birth attendant within reachable distance (Kruk et al., 2018; WHO, 2022).

The Nexus exposes a cruel irony: local social capital is routinely overwhelmed by macro-institutional absence. Communities with the strongest mutual aid are often those most structurally neglected.

Interventions that strengthen community health workers without addressing macro-level workforce, supply, and financing gaps risk exploiting local solidarity while perpetuating systemic failure (Kruk et al., 2018; Scott et al., 2024) (See table 5).

Table 5: Intervention Evaluation through the Public Health Geosociology Lens

Intervention	Spatial Effect	Social Effect	Institutional Effect	Integrated Assessment
Community health workers	Extends reach to remote areas	Relies on local trust and gender matching	Isolated from supply chains, supervision, referral	Partial: improves knowledge and referral but cannot compensate for systemic absence
Mobile clinics	Brings services to dispersed populations	Irregular contact limits trust and continuity	Expensive, parallel to facility system, no integration	Limited: fills gaps temporarily but fragments care
Digital health (mHealth)	Overcomes distance for information	Assumes phone ownership, literacy, network coverage	Does not address facility quality or workforce	Constrained by digital divide; benefits urban, educated, male populations
Transport vouchers	Reduces travel cost barrier	Does not address gender, cultural, or discrimination barriers	Does not improve facility quality or availability	Narrow: solves access cost but not quality or social constraints
Task shifting	Extends procedural capacity to rural areas	May be accepted if from trusted community	Requires supervision, supplies, referral—often absent	Conditional: works where institutional support exists, fails where absent

Source: Authors' synthesis (2026)

6.0 CONCLUSION: Toward a Public Health Geosociology of Practice

Public Health Geosociology provides a comprehensive framework for understanding how health inequality is produced and sustained through the interaction of spatial arrangements, social structures, and institutional power. By integrating the empirical precision of health geography, the structural depth of medical sociology, and the evaluative rigour of public health science, the framework moves beyond fragmented explanations toward a unified, system-level understanding of health inequality in the twenty-first century.

The evidence reviewed in this paper demonstrates that rural health gaps in LMICs are not accidental, natural, or simply a function of individual behaviour. They are socio-spatial fabrications produced by political and economic power, but maintained and enforced by geometric distance. The clustering of facilities in urban centres, the systematic underinvestment in peripheral regions, and the compounding effects of poverty, gender norms,



ethnic discrimination, and weak governance create a *geography of neglect* that transforms physical isolation into health exclusion.

The *vaporization of access* to the non-linear collapse of healthcare utilisation beyond critical distance thresholds shows that statutory rights mean little when the geometry of space is ignored. Near the institutional core, rights are relatively realisable; beyond the threshold, they become practical impossibilities. This is not a logistical problem to be solved by better roads or more clinics alone. It is a structural problem requiring the simultaneous transformation of spatial, social, and institutional arrangements.

The Scale–Sociality Nexus exposes a central paradox: rural communities with the densest local solidarity are often those most structurally abandoned. Their mutual aid cannot compensate for macro-institutional absence. Interventions that exploit local social capital—community health workers, volunteer programmes—without addressing systemic workforce, supply, and financing gaps risk legitimating continued neglect while burning out local capacity.

6.1 Principles for a Public Health Geosociology of Practice

Effective health interventions must move beyond fragmented, single-dimension approaches toward integrated strategies that address space, society, and institutions simultaneously. A Public Health Geosociology of Practice would operate through five principles:

1. **Spatially informed planning:** Use GIS, accessibility modelling, and network analysis to identify institutional deserts and prioritise resource allocation based on need and distance, not political convenience. Map not only where facilities are but where they are reachable given terrain, seasonality, and transport infrastructure (Guagliardo, 2004; Ebener et al., 2021; Ngui & Apparicio, 2011).
2. **Socially embedded implementation:** Integrate qualitative community research spatial ethnography, illness narratives, and participatory mapping to understand how cultural norms, gender constraints, ethnic discrimination, and economic barriers mediate access in specific contexts. Design interventions that are culturally appropriate, gender-sensitive, and economically accessible (Shaikh & Hatcher, 2005; Hamid et al., 2015; Williams & Mohammed, 2013).
3. **Institutionally sustained presence:** Move beyond stopgap measures toward structural health system strengthening. This means workforce policies that attract and retain rural staff through career development, living conditions, and professional support; supply chains that reach peripheral areas reliably; financing mechanisms that pool risk and eliminate user fees; and governance structures that include rural voices in decision-making (Kruk et al., 2018; WHO, 2007; Gilson, 2003).
4. **Scale-crossing integration:** Connect micro-level community health workers to meso-level facility networks and macro-level policy frameworks. Ensure that community-based care is backed by referral transport, facility capacity, and supervisory support. Prevent the isolation of community workers as cheap substitutes for systemic investment (Kruk et al., 2018; Scott et al., 2024).
5. **Equity-driven evaluation:** Assess interventions not only by average outcomes but by their impact on inequality. Use disaggregated data—by place, gender, ethnicity, wealth—to identify whether gaps are narrowing or widening. Employ multilevel methods to distinguish individual, household, and area effects. Evaluate sustainability beyond project timelines (Diez Roux, 2007; Krieger, 2011; Subramanian et al., 2009).



6.2 Implications for Global Health Policy

Public Health Geosociology offers the analytical tools for this transformation. It enables planners to see health systems not as abstract networks but as spatial regimes that distribute life chances across territory. It enables sociologists to locate social power in concrete places rather than abstract structures. It enables epidemiologists to measure not only disease but the structural production of disease through space, society, and institutions.

The integration is urgent. COVID-19 revealed how geographic position and facility access dictated mortality (WHO, 2022). Climate change is pushing marginalised populations into hazardous zones while affluent groups occupy protected spaces (IPCC, 2022). Mass migration shows people fleeing regions where socio-spatial infrastructure has collapsed (World Bank, 2023; UN DESA, 2024). These crises cannot be understood or addressed by disciplines working in isolation.

Public Health Geosociology is not merely an academic framework. It is a political project an argument that health equity requires territorial justice, that universal coverage requires dismantling the structural violence of distance, and that the right to health must be realised in specific places for specific people, not as a national average but as a lived reality. Only by actively identifying, disrupting, and rectifying the geography of neglect can global health policy move beyond core protection and advance toward genuine human development across all borders.



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