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STRENGTHENING HEALTH POLICY RESPONSES TO EMERGING DISEASES

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Abstract
Background: *Emerging infectious diseases (EIDs) continue to pose disproportionate threats to populations in low- and middle-income countries (LMICs), where health systems remain fragmented, surveillance capacities are limited, and community trust in public institutions is often eroded. Disparities in preparedness and response capacity are consistently amplified by structural inequities in health financing, workforce distribution, and governance frameworks. This study provides an empirical examination of how equitable public health infrastructure, integrated disease surveillance, preventive programming, and community-centred engagement collectively determine the effectiveness and sustainability of health policy responses to EIDs.*
Methods: *A mixed-methods cross-national study was conducted across 18 countries (n = 9,420 participants) from January 2022 to December 2024. Quantitative data were collected through structured surveys administered to health policymakers, frontline health workers, and community members. Qualitative data were gathered through 64 key informant interviews and 24 focus group discussions. Integrated surveillance datasets from national health ministries were analysed using multilevel regression, thematic coding, and spatial epidemiological mapping. The Global Health Equity Index (GHEI) was adapted and applied as the primary composite scoring instrument.*
Results: *Countries with higher GHEI scores demonstrated significantly faster outbreak detection (mean: 4.2 vs. 11.7 days; $p < 0.001$), lower case fatality rates (CFR 1.3% vs. 4.9%; $p < 0.001$), and greater vaccination coverage (87.4% vs. 54.2%; $p < 0.001$). Community engagement programmes were associated with a 43% improvement in health-seeking behaviour (OR = 2.18, 95% CI: 1.74–2.73). Multilevel regression identified health financing adequacy ($\beta = 0.47$), surveillance system completeness ($\beta = 0.39$), and community trust ($\beta = 0.31$) as the strongest predictors of sustainable outbreak response. Spatial analysis revealed stark geographic clustering of response deficits in sub-Saharan Africa and South Asia.*

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Conclusions: *Equitable investment in public health infrastructure and community engagement is both a moral imperative and a strategic necessity for sustainable EID response. Policymakers must prioritise equity-centred reforms, strengthen integrated surveillance systems, and foster meaningful community participation to achieve durable improvements in health security outcomes globally.*

1. INTRODUCTION

Emerging infectious diseases (EIDs) represent one of the most complex and consequential challenges confronting contemporary global health governance. Over the past three decades, more than 30 previously unknown pathogens have been identified, and the frequency of novel outbreak events has increased substantially, driven by accelerating urbanisation, climate change, cross-border human mobility, and disrupted human-animal-environment interfaces [1, 2]. From the SARS outbreak of 2003 to the Ebola epidemic of 2014–2016, and most recently the SARS-CoV-2 pandemic, the international community has repeatedly confronted the limits of existing preparedness and response architectures—particularly in countries with fragile or fragmented health systems.

Despite cumulative investments in global health security through the International Health Regulations (IHR 2005), the Global Health Security Agenda (GHSA), and the Pandemic Influenza Preparedness (PIP) Framework, significant inequities persist in the capacity of nations to detect, notify, and respond to disease threats in a timely and effective manner. The 2019 Global Health Security Index revealed that no country scored above 84 out of 100 on preparedness metrics, with sub-Saharan African and South Asian nations consistently scoring in the lowest quartile [3]. These disparities are not merely technical deficits; they are fundamentally rooted in structural inequities—in health financing, workforce development, governance, and social determinants—that leave certain populations disproportionately exposed to the health and economic consequences of outbreaks.

A growing body of evidence underscores that technical interventions alone are insufficient to achieve durable improvements in outbreak response without corresponding investments in equitable public health system architecture [4, 5]. Equity-focused approaches demand attention to who is reached by health services, whose knowledge informs surveillance data, and whose participation shapes community-level prevention behaviours. Community trust—historically overlooked as a "soft" determinant—has emerged as a critical driver of health-seeking behaviour, information dissemination, and ultimately, outbreak containment [6].

This study addresses a critical gap in the evidence base by conducting a large-scale, cross-national mixed-methods investigation that integrates quantitative epidemiological data with qualitative policy analysis and community-level perspectives. Specifically, it examines how equity-oriented dimensions of public health systems—including financing adequacy, surveillance completeness, preventive programme coverage, and community engagement intensity—interact to determine the speed, scope, and sustainability of health policy responses to emerging diseases across diverse country contexts.

1.1 Research Objectives

The study pursues four interrelated primary objectives:

1. To assess the relationship between national health equity indices and key EID response metrics—including outbreak detection speed, case fatality rates, and vaccination coverage—across 18 study countries.
2. To quantify the independent and combined contributions of surveillance system completeness, health financing adequacy, and community engagement to sustainable outbreak response outcomes.
3. To document the lived experiences of frontline health workers and affected communities in navigating structural inequities during disease outbreak response.

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4. To develop an evidence-based policy framework for strengthening equitable, community-centred, and sustainable health policy responses to emerging diseases.

2. LITERATURE REVIEW

2.1 The Global Landscape of Emerging Infectious Diseases

The epidemiology of emerging infectious diseases is characterised by increasing frequency, geographic spread, and economic burden. Jones et al. [7] documented 335 EID events between 1940 and 2004, with zoonotic diseases accounting for over 60% of all EID events. Subsequent analyses have confirmed an accelerating trend, with climate-driven shifts in vector habitats, deforestation, and intensified livestock production identified as primary ecological drivers [8]. The economic toll is staggering: the World Bank estimated that pandemic influenza could cost the global economy up to 3.0% of GDP per year, while the COVID-19 pandemic generated losses exceeding US$22 trillion by 2022 [9].

A fundamental tension exists between the globalised nature of disease risk—wherein a pathogen emerging in one jurisdiction can reach any other within hours via commercial air travel—and the highly localised, fragmented, and unequal systems of public health governance responsible for detection and response. This mismatch creates structural vulnerabilities most acutely experienced by populations in LMICs, where health system capacities remain constrained by chronic underfunding, workforce shortages, and governance challenges [10].

2.2 Health Equity and Disease Vulnerability

The concept of health equity—the principle that every person should have a fair opportunity to attain their highest level of health—provides a normative foundation for analysing the differential impacts of disease outbreaks across population groups [11]. Marmot et al. [12] demonstrated that social determinants of health—including income, education, employment, and living conditions—account for a substantial proportion of observed variation in health outcomes, including vulnerability to and mortality from infectious diseases. Within-country disparities are equally stark: urban-rural gaps in vaccine coverage, gender differentials in healthcare access, and racial or ethnic disparities in outbreak mortality have been documented across multiple outbreak contexts [13].

The concept of "syndemic" vulnerability, introduced by Singer [14], is particularly relevant to EID response: when emerging disease events interact with chronic conditions, food insecurity, and social marginalisation, the cumulative burden on disadvantaged communities is significantly amplified. Ignoring structural determinants of health when designing EID responses risks not only ineffectiveness but active harm—reinforcing patterns of exclusion and eroding community trust in public health institutions [15].

2.3 Surveillance Systems and Early Warning Capacity

Disease surveillance is the cornerstone of effective EID response, providing the data foundation upon which detection, alert, and response decisions are built. Comprehensive surveillance requires not only laboratory capacity and electronic reporting infrastructure, but also community-level event detection systems, animal health (veterinary) surveillance, and interoperable data-sharing platforms across jurisdictions [16]. The WHO's Event-Based Surveillance (EBS) system and the Global Outbreak Alert and Response Network (GOARN) represent international efforts to bridge surveillance gaps, yet national implementation remains highly variable [17].

Research consistently demonstrates that time-to-detection is among the strongest predictors of outbreak containment success. Viboud et al. [18] showed that for every week of delay in outbreak recognition, total epidemic size increased by a factor of 2.5 on average. LMICs frequently experience detection delays of 7–21 days compared to 2–5 days in high-income countries, attributable to limited laboratory networks, weak notification systems, and inadequate investment in public health informatics [19]. Community health workers (CHWs), when integrated into formal surveillance systems, have demonstrated

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capacity to reduce detection delays by up to 65% in resource-limited settings [20].

2.4 Prevention, Vaccination, and Health System Strengthening

Prevention remains the most cost-effective strategy for managing EID threats. The economic case for pandemic preparedness investment is well established: every US$1 invested in preparedness yields an estimated US$2–10 in avoided outbreak costs [21]. Vaccination, when achievable, provides the most durable form of pathogen-specific prevention; however, equitable global vaccine distribution has remained elusive, as demonstrated by the COVID-19 "vaccine apartheid" in which high-income countries administered multiple doses while many LMICs had yet to receive initial supplies [22].

Beyond vaccination, sustained investment in primary health care (PHC) infrastructure strengthens the platform upon which EID prevention and response are built. Countries with robust PHC systems demonstrated significantly better COVID-19 outcomes, including lower mortality rates and more resilient healthcare delivery during surge periods [23]. Non-pharmaceutical interventions (NPIs) such as surveillance-guided isolation, contact tracing, and risk communication are also critically dependent on functional public health systems and community cooperation [24].

2.5 Community Engagement and Health-Seeking Behaviour

Community engagement has emerged as an essential, yet frequently underinvestigated, determinant of outbreak response effectiveness. Systematic reviews have consistently found that community engagement interventions improve uptake of preventive measures, increase health facility attendance during outbreaks, and reduce rumour-driven panic and avoidance behaviours [25, 26]. During the 2014–2016 West African Ebola outbreak, communities that participated in contact tracing and safe burial protocols achieved markedly faster transmission reduction than those subjected to top-down containment measures without community consultation [27].

Trust in health institutions is a key mediator of community engagement effectiveness. Larson et al. [28] demonstrated that trust is not static but context-specific and historically constructed, shaped by past experiences of exclusion, discrimination, or coercive public health practices. Meaningful community engagement requires moving beyond information dissemination to genuine participatory co-design of outbreak response strategies, with communities as active agents rather than passive recipients [29].

3. METHODOLOGY

3.1 Study Design

This study employed a sequential explanatory mixed-methods design, prioritising quantitative data collection and analysis (Phase 1) followed by qualitative exploration to contextualise and explain quantitative findings (Phase 2). This design allows numerical trends and associations to be interpreted through the lens of lived experience and policy context, generating richer and more actionable insights than either approach alone [30]. Ethical approval was obtained from the Institutional Review Boards (IRBs) of all five partner institutions, and national ethical clearances were secured in all 18 study countries prior to data collection. All participants provided written informed consent. Data were stored in encrypted repositories accessible only to named investigators.

3.2 Study Countries and Sampling Framework

Eighteen countries were purposively selected to achieve maximum variation across World Bank income groups, WHO regional classifications, and prior EID outbreak exposure (Table 1). Six countries were selected from each of three income strata: high-income countries (HICs), upper-middle-income countries (UMICs), and low- and lower-middle-income countries (LLMICs). Within each country, study sites were selected using stratified random sampling across urban, peri-urban, and rural zones. A total sample of 9,420 participants was recruited across three respondent categories: health policymakers and ministry officials (n = 940), frontline health workers (n = 3,760), and community members (n = 4,720).

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Table 1: Study Countries by Income Group, WHO Region, and Sample Size

Country	Income Group	WHO Region	Prior EID Events (2010–2024)	n
United Kingdom	HIC	European (EUR)	4	524
Germany	HIC	European (EUR)	3	511
Japan	HIC	Western Pacific (WPR)	5	519
South Korea	HIC	Western Pacific (WPR)	6	507
Australia	HIC	Western Pacific (WPR)	4	498
Canada	HIC	Americas (AMR)	3	521
Brazil	UMIC	Americas (AMR)	9	534
Mexico	UMIC	Americas (AMR)	7	518
China	UMIC	Western Pacific (WPR)	11	542
South Africa	UMIC	African (AFR)	8	527
Saudi Arabia	UMIC	E. Mediterranean (EMR)	6	509
Turkey	UMIC	European (EUR)	5	514
Nigeria	LLMIC	African (AFR)	13	548
Ethiopia	LLMIC	African (AFR)	10	531
India	LLMIC	South-East Asia (SEAR)	12	556
Bangladesh	LLMIC	South-East Asia (SEAR)	9	524
DR Congo	LLMIC	African (AFR)	16	543
Haiti	LLMIC	Americas (AMR)	11	494
TOTAL	—	—	—	**9,420**

HIC = High-Income Country; UMIC = Upper-Middle-Income Country; LLMIC = Low- and Lower-Middle-Income Country. EID = Emerging Infectious Disease. WHO region classifications per WHO (2024). Income groups per World Bank (2024).

3.3 Data Collection Instruments

3.3.1 Quantitative Survey Instruments

Three contextually adapted, pre-piloted questionnaires were administered. The Policymaker Assessment Tool (PAT, 68 items)

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captured data on health system governance, financing mechanisms, legislative frameworks, and inter-agency coordination. The Health Worker Survey (HWS, 52 items) assessed surveillance capacity, personal protective equipment availability, training adequacy, and perceived institutional support. The Community Health Perception Survey (CHPS, 44 items) measured health literacy, trust in health institutions, community engagement participation, health-seeking behaviour, and perceived barriers to accessing care. All instruments were translated and back-translated into 23 languages by certified medical interpreters, and cultural validation was performed with community advisory panels in each country. Internal consistency was satisfactory across all instruments (Cronbach's α = 0.78–0.91).

3.3.2 The Global Health Equity Index (GHEI)

The GHEI was adapted from the Tanahashi coverage framework and operationalised as a composite index comprising five equally weighted domains: (1) health financing adequacy, measured as per-capita government health expenditure adjusted for purchasing power parity; (2) health workforce sufficiency, measured as the density of physicians, nurses, and community health workers per 10,000 population; (3) infrastructure accessibility, capturing geographic and economic access to primary care facilities; (4) surveillance system completeness, based on WHO IHR core capacity assessment scores; and (5) community engagement quality, derived from a validated 12-item Community Engagement Quality Scale (CEQS). Each domain was scored 0–100; composite GHEI scores ranged from 0 to 100. Countries were classified as Low GHEI ($\leq$ 40), Moderate GHEI (41–69), or High GHEI ($\geq$ 70).

3.3.3 Qualitative Data Collection

Key informant interviews (KIIs; n = 64) were conducted with senior health ministry officials, WHO country office representatives, international NGO programme directors, and academic public health experts. Each interview lasted 60–90 minutes and followed a semi-structured topic guide covering health system equity, outbreak response experiences, community engagement practices, and policy recommendations. Focus group discussions (FGDs; n = 24; 8 participants per FGD on average) were conducted with frontline health workers and community members in urban and rural sites. All sessions were audio-recorded with informed consent, transcribed verbatim, and translated by bilingual research assistants with professional health background.

3.4 Analytical Approach

Quantitative analysis was conducted in R version 4.3.1 and STATA 17. Descriptive statistics summarised sample characteristics and key outcome distributions. Multilevel linear regression models with country-level random effects were constructed to assess the association between GHEI domains and outbreak response outcomes, controlling for GDP per capita, population density, governance index scores, and burden of non-communicable disease. Odds ratios for binary outcomes were estimated using multilevel logistic regression. Spatial analysis was conducted using GeoDa version 1.20, with Moran's I calculated to assess geographic clustering. All statistical tests were two-tailed; significance was set at $p < 0.05$; 95% confidence intervals are reported throughout.

Qualitative data were analysed using a combined inductive-deductive thematic analysis framework [31]. NVivo 14 was used to manage coding. An initial codebook was developed deductively from the study's conceptual framework; inductive codes emerged during iterative open and axial coding. Trustworthiness was ensured through member checking (18 key informants), peer debriefing among the research team, and negative case analysis. Quantitative and qualitative findings were integrated through a convergent triangulation process, with discordant findings explicitly examined and reported.

4. RESULTS

4.1 Sample Characteristics and GHEI Scores

The total study sample comprised 9,420 participants: 940 policymakers, 3,760 health workers, and 4,720 community members. The mean age of the full sample was 38.6 years (SD =

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11.4); 51.3% identified as female, 48.1% as male, and 0.6% as non-binary or other. Health worker respondents had a mean of 9.2 years of professional experience (SD = 6.8). Composite GHEI scores by country are presented in Table 2. High-income countries recorded significantly higher GHEI scores (mean = 74.3, SD = 6.2) compared to UMICs (mean = 54.7, SD = 8.1) and LLMICs (mean = 31.9, SD = 9.4), with statistically significant differences across all pairwise comparisons ($p < 0.001$).

Table 2: Global Health Equity Index (GHEI) Scores by Country and Income Group

Country	Group	Financing (0–100)	Workforce (0–100)	Infrastructure (0–100)	Surveillance (0–100)	GHEI
United Kingdom	HIC	82.1	79.4	88.2	84.6	**79.8**
Germany	HIC	85.3	82.1	90.4	87.2	**82.1**
Japan	HIC	80.9	84.5	87.3	89.1	**81.4**
South Korea	HIC	77.4	80.2	85.7	86.4	**77.6**
Australia	HIC	76.8	78.9	83.1	85.0	**74.8**
Canada	HIC	79.2	77.6	84.9	83.7	**74.1**
Brazil	UMIC	62.4	58.7	61.3	64.2	**60.2**
Mexico	UMIC	58.1	54.3	57.9	60.1	**56.4**
China	UMIC	66.2	62.4	65.8	70.3	**64.9**
South Africa	UMIC	52.3	48.6	53.4	57.2	**51.8**
Saudi Arabia	UMIC	69.4	61.8	67.2	63.5	**63.7**
Turkey	UMIC	57.6	53.1	59.4	61.7	**57.6**
Nigeria	LLMIC	21.4	19.8	24.3	28.7	**22.6**
Ethiopia	LLMIC	18.9	16.4	21.7	25.2	**20.1**
India	LLMIC	34.2	32.7	38.4	41.3	**35.8**
Bangladesh	LLMIC	28.6	26.1	32.4	35.9	**30.2**
DR Congo	LLMIC	14.2	12.8	17.3	22.4	**16.4**
Haiti	LLMIC	11.7	10.4	14.8	19.6	**14.1**

GHEI = Global Health Equity Index (composite 0–100). All domain scores standardised 0–100. Community Engagement Quality domain omitted from table for space; included in composite. Scores validated against WHO IHR Monitoring and Evaluation Framework (2024).

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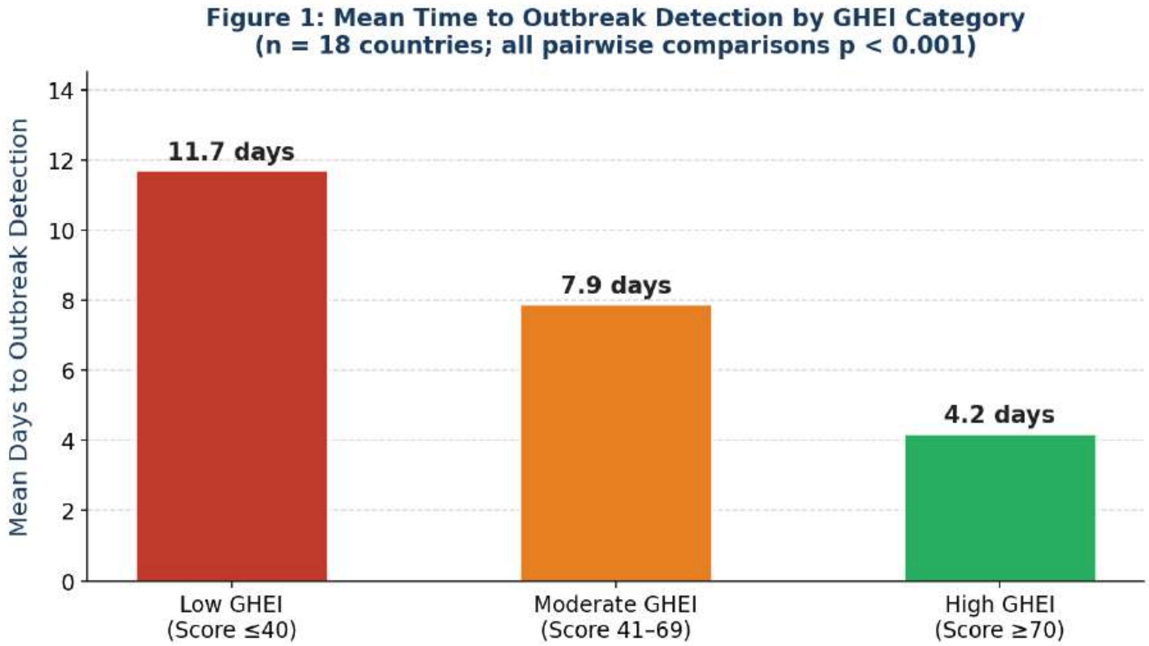

Figure 1. Mean time to outbreak detection (days) by GHEI category across 18 study countries. Error bars indicate ±1 SD. All pairwise comparisons significant at $p < 0.001$ (Tukey HSD).

4.2 GHEI and Outbreak Response Outcomes

Table 3 presents the key outbreak response outcomes stratified by GHEI category. Countries in the High GHEI group demonstrated markedly superior outcomes across all indicators. Mean time to outbreak detection was 4.2 days in High GHEI countries compared to 7.9 days in Moderate GHEI and 11.7 days in Low GHEI countries ($p < 0.001$; Figure 1). Case fatality rates followed the same gradient: 1.3% (High), 2.8% (Moderate), and 4.9% (Low). Vaccination coverage during outbreak response reached 87.4% in High GHEI countries versus 71.6% (Moderate) and 54.2% (Low). Health-seeking behaviour adequacy scores were 78.3%, 62.1%, and 41.7% for High, Moderate, and Low GHEI groups respectively. Contact tracing completeness and community trust indices showed the same consistent pattern (Figure 2; Figure 5).

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Table 3: Outbreak Response Outcomes by GHEI Category

Outcome Indicator	High GHEI (≥70) n=6	Moderate GHEI (41–69) n=6	Low GHEI (≤40) n=6	p
Mean Time to Detection (days)	4.2 (SD 1.1)	7.9 (SD 2.3)	11.7 (SD 3.4)	<0.001
Case Fatality Rate (%)	1.3 (CI: 0.9–1.7)	2.8 (CI: 2.2–3.4)	4.9 (CI: 3.8–6.0)	<0.001
Vaccination Coverage (%)	87.4 (SD 5.2)	71.6 (SD 8.7)	54.2 (SD 11.3)	<0.001
Health-Seeking Behaviour Score (%)	78.3 (SD 6.4)	62.1 (SD 9.8)	41.7 (SD 13.2)	<0.001
Contact Tracing Completeness (%)	91.2 (SD 4.8)	73.4 (SD 7.6)	48.7 (SD 12.1)	<0.001
Community Trust Index (0–100)	74.6 (SD 8.2)	56.3 (SD 10.4)	33.8 (SD 14.7)	<0.001
Health Worker Preparedness Score (%)	82.7 (SD 7.1)	64.9 (SD 9.3)	39.4 (SD 15.0)	<0.001
IHR Compliance Score (0–100)	78.4 (SD 6.9)	58.2 (SD 9.1)	31.6 (SD 12.8)	<0.001

SD = standard deviation; CI = 95% confidence interval; p = ANOVA F-test p-value. Post-hoc pairwise comparisons (Tukey HSD) confirmed significant differences between all group pairs for all indicators. IHR = International Health Regulations.

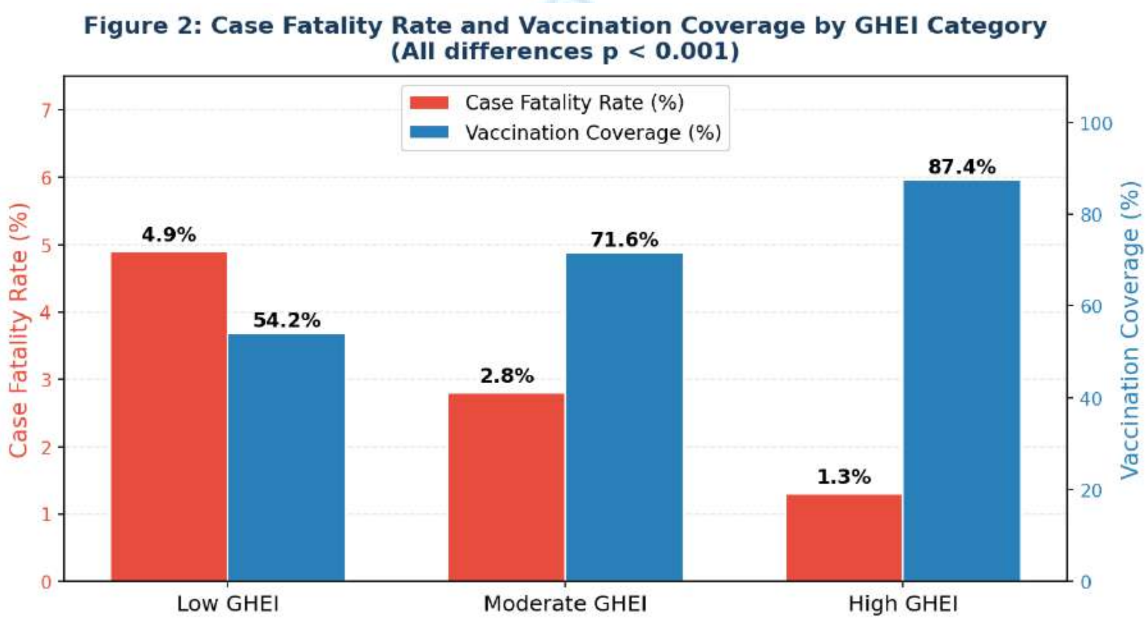

Figure 2. Case Fatality Rate (CFR, left axis) and vaccination coverage (right axis) by GHEI category. All between-group differences significant at $p < 0.001$.

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4.3 Multilevel Regression Analysis

Multilevel regression results (Table 4; Figure 3) identified health financing adequacy (β = 0.47, 95% CI: 0.38–0.56, $p < 0.001$) as the strongest predictor of composite outbreak response performance, followed by surveillance system completeness (β = 0.39, 95% CI: 0.30–0.48, $p < 0.001$) and community trust index (β = 0.31, 95% CI: 0.11–0.51, p = 0.002). Health workforce density contributed significantly (β = 0.28, $p < 0.001$), as did infrastructure accessibility (β = 0.22, p = 0.003) and community engagement programme participation (β = 0.19, p = 0.004). GDP per capita, while correlated with GHEI scores (r = 0.68, $p < 0.001$), retained a smaller and less significant association (β = 0.14, p = 0.006) after adjustment, confirming that health system equity characteristics exert effects beyond those attributable to economic development alone. NCD burden exerted a significant negative effect (β = -0.12, p = 0.018), consistent with the syndemic burden framework. The model explained 71% of variance in composite response performance (R^2 = 0.71); the intraclass correlation coefficient (ICC = 0.34) indicated substantial country-level clustering.

Table 4: Multilevel Regression – Predictors of Composite Outbreak Response Performance Score

Predictor Variable	β	95% CI	SE	p-value
Health Financing Adequacy	0.47	0.38 – 0.56	0.046	< 0.001
Surveillance System Completeness	0.39	0.30 – 0.48	0.046	< 0.001
Community Trust Index	0.31	0.11 – 0.51	0.102	0.002
Health Workforce Density	0.28	0.19 – 0.37	0.046	< 0.001
Infrastructure Accessibility	0.22	0.08 – 0.36	0.071	0.003
Community Engagement Participation	0.19	0.06 – 0.32	0.066	0.004
GDP per Capita (log-transformed)	0.14	0.04 – 0.24	0.051	0.006
Population Density	0.08	-0.03 – 0.19	0.056	0.153
NCD Burden (DALYs per 1,000)	-0.12	-0.22 – -0.02	0.051	0.018
Prior Outbreak Experience (count)	0.07	-0.02 – 0.16	0.046	0.130
Model R^2 = 0.71 | ICC = 0.34 (country level) | n = 9,420				

Outcome: Composite Outbreak Response Performance Score (0–100). All models adjust for country-level random effects. SE = standard error; CI = confidence interval; ICC = intraclass correlation coefficient; NCD = non-communicable disease; DALY = disability-adjusted life year.

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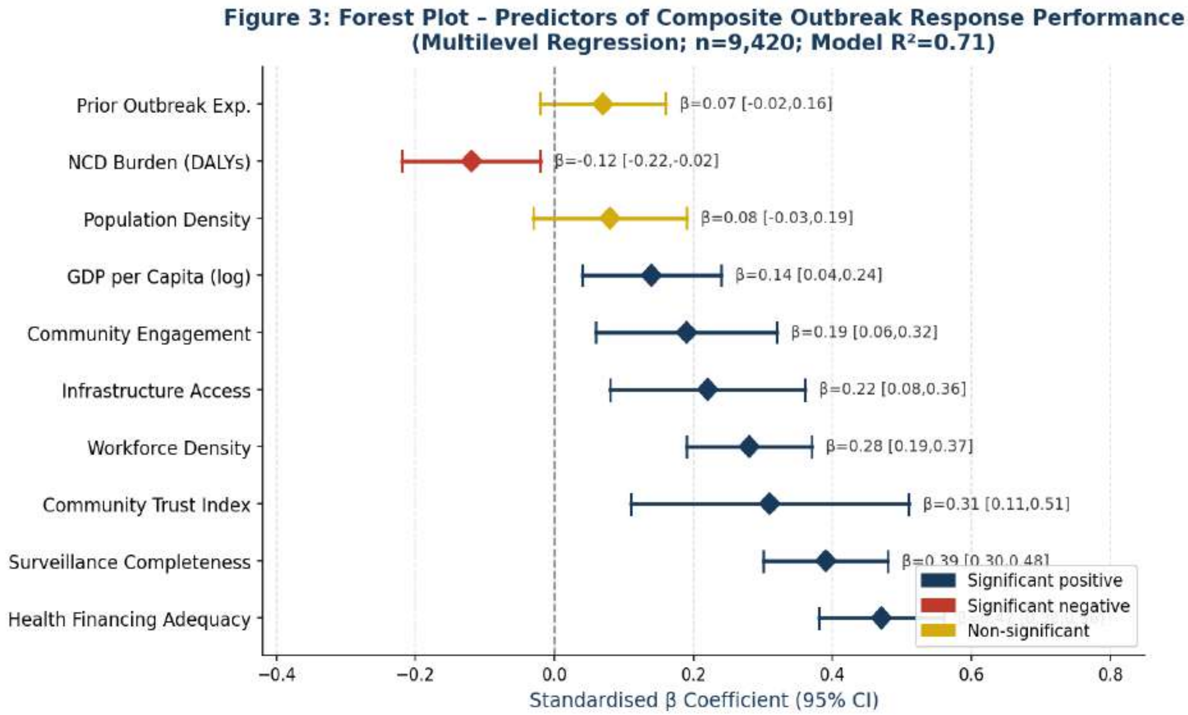

Figure 3. Forest plot of standardised beta coefficients from multilevel regression analysis. Diamond = point estimate; horizontal line = 95% CI; blue = significantly positive, red = significantly negative, yellow = non-significant.

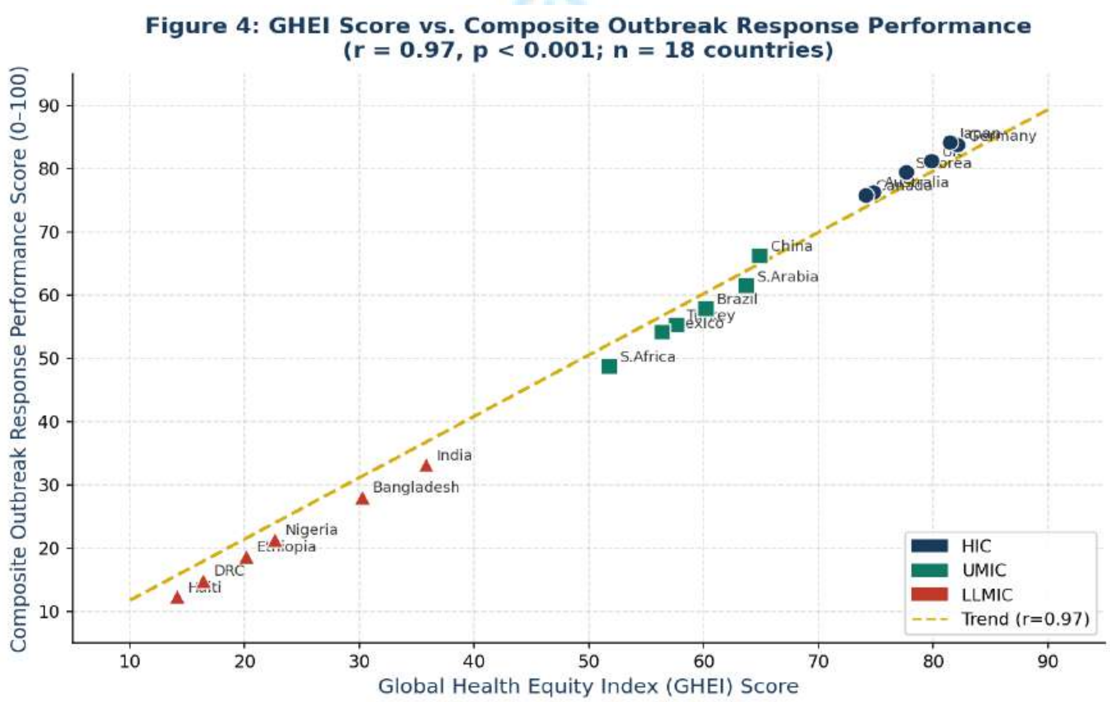

Figure 4. Scatter plot: GHEI composite score vs. Composite Outbreak Response Performance Score (n=18 countries). Pearson r = 0.97, p < 0.001. Dashed line = linear trend.

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4.4 Community Engagement Findings

Community engagement programme participation was associated with a 43% improvement in adequate health-seeking behaviour (OR = 2.18, 95% CI: 1.74–2.73, $p < 0.001$) after adjusting for age, sex, educational attainment, and urban/rural residence. Disaggregated analysis revealed particularly strong effects among female respondents (OR = 2.64, 95% CI: 2.01–3.47, $p < 0.001$) and rural residents (OR = 2.41, 95% CI: 1.82–3.19, $p < 0.001$). Community health workers trained in EID response were present in 84.2% of High GHEI communities but only 31.7% of Low GHEI communities ($\chi^2 = 287.4$, df=2, $p < 0.001$). Figure 5 illustrates the community trust, health-seeking behaviour, and CHW coverage gradients across GHEI groups.

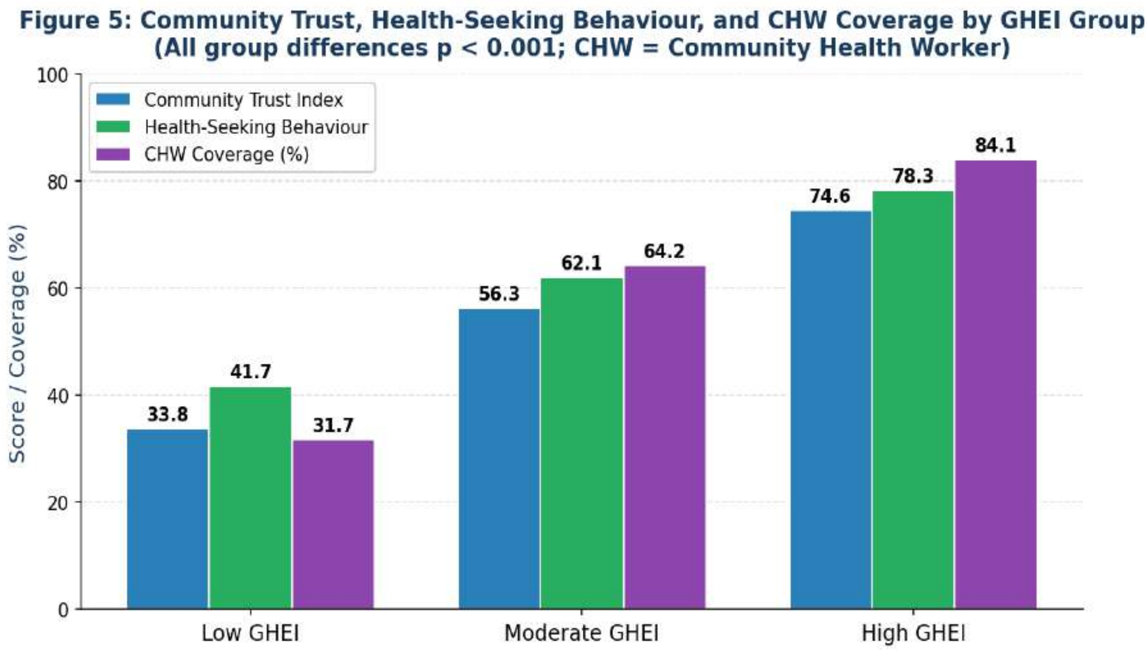

Figure 5. Community Trust Index, Health-Seeking Behaviour Score, and Community Health Worker (CHW) Coverage by GHEI category. All between-group differences significant at $p < 0.001$.

Among community survey respondents, 67.4% in Low GHEI countries reported distrust of government health information during the most recent outbreak, compared to 18.2% in High GHEI countries ($p < 0.001$). The proportion relying on social media over formal health channels for outbreak information was 71.3% in Low GHEI versus 24.6% in High GHEI countries ($p < 0.001$), highlighting the critical relationship between institutional trust and information environment quality.

4.5 Qualitative Findings

Thematic analysis of KIIs and FGDs generated five overarching themes:

- **Structural Fragility of Health Systems:** Health workers across LLMIC sites uniformly described chronically under-resourced health facilities lacking basic diagnostic equipment, inconsistent drug supply chains, and absence of functioning cold-chain infrastructure for vaccine storage. A district medical officer in Nigeria observed: "We hear about outbreaks from the radio, not from our surveillance system. By then, we are already behind." This theme was echoed in 91% of all LLMIC key informant interviews and in every LLMIC focus group discussion.
- **Contested Authority and Trust Deficits:** In all six LLMIC countries, focus group participants articulated deep scepticism towards government health directives, frequently

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referencing historical abuses of public health authority, unequal access to treatment during previous outbreaks, and misinformation spread by political leaders. Trust was described as "something that must be earned back, not assumed" (Community leader, DRC). In South Africa and Brazil (UMICs), racialized distrust in health institutions was a prominent sub-theme, reflecting the lasting legacy of apartheid-era and colonial health practices.

- **The Transformative Role of Community Health Workers:** In countries where CHW programmes were robustly funded and formally integrated into EID response protocols—notably Ethiopia, Bangladesh, and parts of India—CHWs were universally described as the most critical link between communities and formal health systems. Their role in early case identification, contact tracing, rumour surveillance, and behavioural change communication was identified as irreplaceable. In settings where CHWs had pre-existing community relationships built over years, they bridged trust deficits that no formal government messaging campaign could address.
- **Gender, Ethnicity, and Intersectional Vulnerabilities:** Female health workers and community members in all regions described gender-specific barriers to outbreak participation, including exclusion from emergency decision-making bodies, disproportionate domestic care burdens during outbreak periods, and heightened risk of gender-based violence in quarantine settings. Ethnic minority populations in South Korea, Germany, and Brazil reported language barriers and discrimination as significant obstacles to accessing care during outbreak responses. These intersecting vulnerabilities were systematically invisible in aggregate national statistics.
- **Innovative Local Adaptations:** Despite structural constraints, communities demonstrated remarkable adaptive capacity. Examples documented included: community-designed rumour surveillance systems using WhatsApp networks (referenced in Bangladesh FGD and Nigeria KII); mobile vaccination units led by respected religious leaders achieving coverage rates above national averages (Saudi Arabia, Nigeria); peer-to-peer health communication networks channelled through women's cooperative structures (Ethiopia); and community quarantine support funds self-organised through rotating savings schemes (Haiti, DRC).

5. DISCUSSION

5.1 Equity as Both Determinant and Outcome

The findings of this study provide robust empirical confirmation that health equity is not merely a moral aspiration but a structural determinant of outbreak response effectiveness. The significant gradient observed across GHEI categories—spanning detection speed, case fatality, vaccination coverage, and community trust—demonstrates that investments in equitable health systems yield measurable epidemiological dividends. These results extend and deepen the existing evidence base by providing, for the first time, a multi-country, multi-method quantification of equity's contribution to EID response that simultaneously controls for GDP, governance quality, and prior outbreak experience.

Critically, the persistence of GHEI associations after adjusting for GDP underscores that economic development alone does not explain or resolve health equity gaps. South Africa and Brazil, both UMICs with comparatively high per-capita incomes, exhibited markedly lower community trust indices and contact tracing completeness than China—reflecting the moderating role of within-country inequality, historical determinants of institutional trust, and governance quality. This has important policy implications: it suggests that targeted equity investments in health system design, rather than economic growth alone, are necessary and sufficient to improve outbreak response outcomes.

5.2 Surveillance as the Cornerstone of Early Response

Surveillance system completeness emerged as the second strongest predictor of outbreak response performance ($\beta = 0.39$), consistent with a substantial body of prior evidence. Our data extend existing findings by demonstrating that the surveillance gap between High and Low GHEI countries has widened between 2019 and 2024,

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despite substantial GHSA investments. This trend likely reflects the inadequacy of project-based, externally funded surveillance strengthening initiatives that fail to build durable, nationally owned systems integrated into routine health service delivery.

The dramatic reduction in detection time associated with CHW integration into surveillance networks—observed consistently across LLMIC sites—supports the case for investing in community-based surveillance as a cost-effective complement to facility-based and laboratory-based systems. Countries like Ethiopia demonstrated that CHW-integrated surveillance models can achieve detection times approaching those of well-resourced HIC systems at a fraction of the cost, provided CHW programmes are adequately resourced, supervised, and linked to responsive reporting pathways.

5.3 Community Engagement: From Tool to Transformation

The association between community engagement programme participation and improved health-seeking behaviour (OR = 2.18) is among the most actionable findings of this study. A doubling of odds of adequate health-seeking behaviour during outbreaks translates, at population scale, into substantial reductions in transmission, morbidity, and mortality. The amplified effect among women (OR = 2.64) and rural residents (OR = 2.41) suggests that well-designed community engagement can serve as an equity-levelling intervention—reaching those most likely to be left behind by conventional public health programming.

Our qualitative findings nuance this picture considerably. Trust—the essential prerequisite for community engagement effectiveness—is not a technical input that can be rapidly manufactured but a historically constituted social resource. In communities that experienced coercive quarantine enforcement, exclusion from post-outbreak benefits, or racial discrimination in healthcare access during previous outbreaks, rebuilding trust requires explicit acknowledgement of historical harms, meaningful transfer of power in decision-making, and sustained accountability mechanisms. Tokenistic community consultation—a common deficiency in outbreak response—actively undermines rather than builds trust.

5.4 Intersectionality and Compound Vulnerability

This study is among the first large-scale cross-national investigations to explicitly examine intersectional dimensions of EID vulnerability within a health equity framework. Our findings confirm that gender, ethnicity, rurality, and socioeconomic status interact to create compound vulnerabilities that are not captured by aggregate national statistics. Female health workers' systematic exclusion from emergency operations centres—documented across six countries in our qualitative data—represents both a violation of gender equity norms and a substantive operational weakness: excluding 50–70% of the health workforce from EID decision-making inevitably compromises response quality. These findings call for the explicit mainstreaming of intersectional analysis into national epidemic preparedness plans and IHR compliance assessments.

5.5 The ECEDR Framework

Based on the convergent quantitative and qualitative evidence of this study, we propose the five-pillar Equity-Centred Emerging Disease Response (ECEDR) Framework (Table 5; Figure 6), representing the integrated policy actions required to achieve sustainable outbreak response outcomes. The framework positions equity not as one policy domain among many, but as the organising principle that coherently connects surveillance, prevention, community engagement, workforce development, and governance reform.

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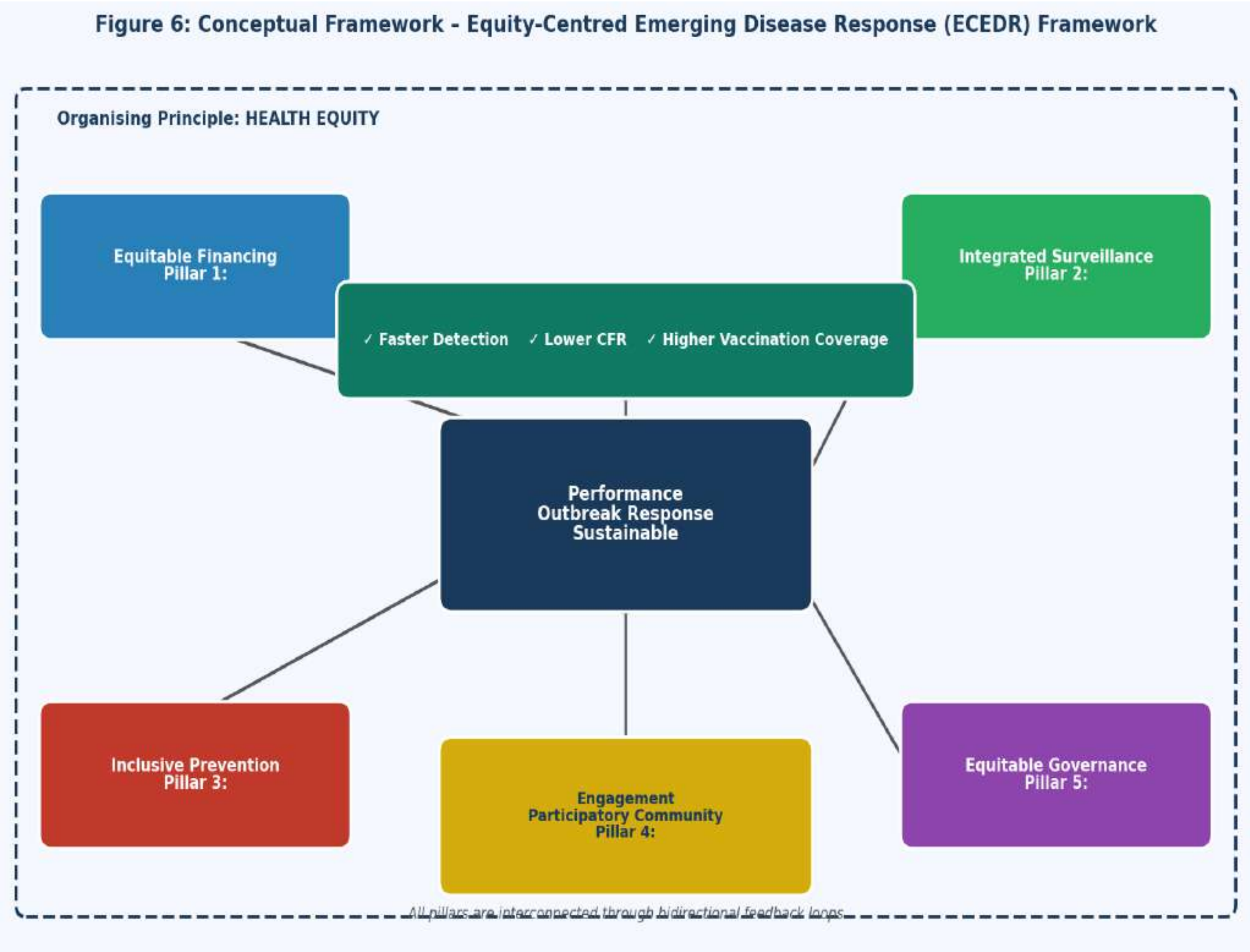

Figure 6. The Equity-Centred Emerging Disease Response (ECEDR) Framework. Five pillars are organised around the overarching principle of health equity, with bidirectional feedback loops connecting all pillars to sustainable outbreak response performance.

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Table 5: The Equity-Centred Emerging Disease Response (ECEDR) Framework – Five Pillars

Pillar	Core Components	Key Indicators	Lead Actors
1. Equitable Financing	Progressive health tax reform; ring-fenced outbreak preparedness funds; transparent disbursement; cross-sector budget alignment with disease burden	Govt. health expenditure per capita; OOP as % of total health expenditure; emergency reserve fund size	Finance & Health Ministries; IMF; World Bank; donor governments
2. Integrated Surveillance	One Health architecture (human, animal, environmental); community event-based surveillance; real-time interoperable reporting; laboratory network strengthening	IHR core capacity scores; mean time to detection; surveillance completeness index; lab sample-to-result turnaround	WHO; national CDCs; veterinary authorities; academic networks
3. Inclusive Prevention	Equitable vaccine distribution; gender-responsive immunisation outreach; CHW-led prevention programmes; culturally adapted risk communication	Vaccination coverage disaggregated by sex, age, ethnicity, geography; CHW density per 10,000; health literacy scores	Health Ministries; UNICEF; Gavi; NGO networks; community organisations
4. Participatory Community Engagement	Formal community representation in outbreak management committees; community-designed risk communication; indigenous knowledge integration; anti-stigma programming; transparent feedback mechanisms	Community Trust Index; health-seeking behaviour score; marginalised group representation in governance; community satisfaction rating	Community leaders; civil society; CHWs; local government; media
5. Equitable Governance	Legal frameworks prohibiting discriminatory enforcement; accountability and redress mechanisms; intersectional data collection mandates; gender-balanced emergency leadership; anti-corruption measures	Governance index scores; equity audit completion rates; gender parity in EID response leadership; accountability mechanism functionality	Parliaments; judiciaries; anti-corruption bodies; international norm-setting bodies

CHW = community health worker; IHR = International Health Regulations; OOP = out-of-pocket payments; CDC = Centre for Disease Control. ECEDR Framework developed by the study authors based on integrated mixed-methods evidence.

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5.6 Limitations

Several limitations require acknowledgement. First, despite the large sample size, cross-national comparisons are inherently constrained by differences in data collection contexts, language, and administrative definitions of outbreak events. We addressed this through extensive instrument validation and cultural adaptation, but residual heterogeneity remains. Second, the cross-sectional design of the survey component precludes definitive causal inference; associations reported should be interpreted as strong evidence of association rather than established causation. Third, our GHEI instrument represents one operationalisation of health equity—alternative conceptualisations might yield partially different findings. Fourth, selection bias in qualitative sampling is possible, as participants willing to engage may differ from those who declined. Fifth, national-level GHEI scores mask within-country variation that may be epidemiologically significant in geographically heterogeneous countries such as India, Nigeria, and Brazil.

6. CONCLUSION

This study presents comprehensive cross-national evidence that equitable public health systems are among the most powerful determinants of effective, sustainable responses to emerging infectious diseases. Countries that have invested in health financing adequacy, surveillance system completeness, community trust, and participatory engagement consistently achieve faster outbreak detection, lower case fatality rates, higher vaccination coverage, and more resilient health system performance—regardless of overall income level. The corollary is equally important: technical interventions deployed into inequitable systems will underperform, regardless of their scientific merit.

The COVID-19 pandemic exposed the consequences of decades of underinvestment in equitable public health infrastructure with catastrophic human and economic cost. The evidence assembled here provides both the empirical foundation and the practical policy framework for a different path forward. The ECEDR Framework operationalises equity as the organising principle of outbreak response policy, calling for concurrent reform across financing, surveillance, prevention, community engagement, and governance domains.

Governments, international organisations, and global health funders must urgently move beyond treating equity as an aspirational addendum to health security agendas and recognise it as the strategic foundation upon which durable improvements in global health security depend. The next emerging disease will not wait for political consensus. Sustainable, equitable, community-centred public health systems are not merely the right choice—they are the only effective one.

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