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Mortality Mapping as a Decision-Support Tool for African Public Health Policy: Review of how GIS-driven Mortality Data Informs Interventions

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Abstract

Mortality mapping has emerged as a transformative decision-support tool for public health policy in Africa. This conceptual review examines how Geographic Information Systems (GIS) and geostatistical methods are being used to generate high-resolution mortality data to inform equitable policy responses, with a focus on Nigeria as a case study. Drawing on peer-reviewed literature and institutional reports, the paper synthesizes evidence on the development, application, and policy implications of GIS-driven mortality mapping. The findings reveal that fine-scale mortality maps expose hidden geographies of child and maternal mortality, highlighting disparities that are obscured by national or state-level averages. By translating complex mortality data into accessible visual formats, GIS supports precision health planning, targeted resource allocation, and improved accountability in governance. However, barriers such as weak civil registration systems, data quality gaps, and limited institutional capacity persist. The study concludes that integrating mortality mapping into national health systems can enhance data-driven decision-making, advance health equity, and accelerate progress toward the Sustainable Development Goals (SDGs) in Africa.

Keywords: Mortality Mapping, Public Health Policy, Health Equity, Child Mortality, Maternal Mortality.

Introduction

Mortality remains one of the most fundamental indicators of population health, shaping national and international policy agendas across Africa. Despite global progress in reducing under-five and maternal mortality since 2000, sub-Saharan Africa still bears a disproportionate share of preventable deaths, with Nigeria alone accounting for an estimated 12% of global under-five mortality in 2022 [1]. Within- country inequalities are particularly striking, as national averages often conceal extreme subnational disparities, with mortality risk varying substantially across states, districts, and even communities [2]. This spatial heterogeneity underscores the urgent need for granular, geographically sensitive tools to inform equitable policy responses.

Geographic Information Systems (GIS) and advances in small-area estimation have transformed the ability to generate high-resolution mortality maps for African countries. Model-based geostatistical approaches now leverage household surveys, censuses, and health facility data to estimate mortality at resolutions as fine as 5×5 km [3]. These methods not only reveal where mortality risk is highest but also allow decision makers to compare administrative averages with localized hotspots, thereby aligning resource allocation with actual need. In countries like Nigeria, where health outcomes are shaped by a combination of demographic pressures, fragile health systems, and persistent inequality, the integration of GIS-driven mortality evidence into planning offers a powerful pathway toward precision public health [4].

The use of mortality mapping as a decision-support tool is still emerging across African ministries of health. While initiatives by UNICEF, WHO, and the Institute for Health Metrics and Evaluation (IHME) have produced continental and national maps of child mortality, the translation of these products into routine policy processes remains uneven [5]. Barriers include gaps in civil registration and vital statistics (CRVS), limited local technical capacity to interpret model outputs, and institutional inertia in adopting new data tools. Nonetheless, early examples suggest that mortality mapping can reorient interventions, such as immunization campaigns and maternal health programs, toward underserved areas [6].

Mortality statistics have long been considered the most fundamental barometer of population health, serving as a mirror of the broader socioeconomic and political conditions of a nation. In the African context, where health inequities remain stark, mapping mortality provides not only a diagnostic lens but also a moral imperative to identify and address the "where" of preventable deaths. By situating mortality outcomes in space, policymakers are confronted with the geographic distribution of health risks, which is often more compelling than abstract national averages. This framing transforms statistics into actionable knowledge, making it difficult to overlook neglected regions where child and maternal deaths remain disproportionately high.

In Nigeria, the persistent mortality gap between northern and southern states exemplifies how spatial analysis highlights entrenched inequities. Mortality mapping thus functions as both a technical and political act, compelling leaders to acknowledge and respond to geographic injustice in health outcomes. The introduction of geospatial tools has also shifted the narrative from mortality being a retrospective indicator to becoming a prospective planning tool. This evolution underscores the urgency of embedding mortality mapping within public health strategy, ensuring it informs forward-looking policies rather than merely chronicling past failures.

This paper presents a conceptual review of how GIS-driven mortality data have been developed and applied in African contexts, with Nigeria as a focal case study. It synthesizes evidence from recent literature and policy reports to evaluate the potential of mortality mapping as a decision-support instrument. By examining both technical advances and institutional challenges, the paper proposes a roadmap for embedding geospatial mortality analytics into African public health planning. In doing so, it addresses the broader question of how high-resolution mortality data can help close equity gaps, accelerate progress toward the Sustainable Development Goals, and strengthen accountability in health governance.

Conceptual Framework

The value of mortality mapping for African public health policy rests on its ability to act as a structured decision-support tool. At its core, decision support involves transforming raw data into actionable insights that guide policy choices, resource allocation, and intervention design. For mortality mapping, this transformation can be conceptualized as a multi-stage pathway: data generation, geospatial modelling, visualization, decision processes, and policy outcomes. Each stage involves technical, institutional, and political dimensions that determine whether spatial mortality evidence ultimately informs real-world action.

The conceptual framework adopted here views mortality mapping as a cyclical process rather than a linear chain of events. Data collection feeds into modelling, modelling generates visualization, visualization informs decision-making, and the decisions taken inevitably influence subsequent data cycles through improved surveillance and monitoring. At the data generation stage, it is crucial to recognize the limitations of household surveys and the incompleteness of civil registration systems. These challenges reinforce the importance of triangulating multiple sources, including satellite imagery and routine health records, to create more comprehensive mortality surfaces.

The modelling stage reflects the methodological sophistication underpinning mortality mapping. Bayesian and geostatistical techniques allow researchers to estimate mortality at fine spatial scales, filling the gaps where direct observations are lacking. This transforms scattered survey clusters into continuous surfaces of mortality risk. Visualization plays a communicative role, translating complex statistical models into intuitive maps that can be understood by policymakers, journalists, and the general public. Without visualization, the outputs of sophisticated models risk remaining inaccessible to those who most need the evidence.

Finally, policy outcomes represent the most critical test of the framework. A mortality map that does not influence policy is a technical artifact rather than a decision-support tool. The framework thus emphasizes the necessity of closing the loop between knowledge generation and tangible health system action.

The first stage, data generation, draws on diverse sources including household surveys such as the Demographic and Health Surveys (DHS) and Multiple Indicator Cluster Surveys (MICS), censuses, civil registration and vital statistics (CRVS) systems, and health facility data. In Nigeria, for example, DHS surveys remain a primary source of mortality data, but incomplete CRVS systems and patchy health facility reporting limit the comprehensiveness of available records [7]. The unevenness of these data sources requires statistical innovation to fill gaps and ensure comparability across regions.

The second stage is geospatial modelling, where advanced statistical approaches, such as Bayesian model-based geostatistics and small-area estimation, integrate multiple datasets to generate fine-scale mortality estimates [8]. These models can interpolate mortality risk for areas with sparse or missing data while quantifying the uncertainty associated with predictions. By applying such methods at high spatial resolution, analysts can produce mortality surfaces that reveal patterns invisible in national or even state-level averages. For Nigeria, this means identifying clusters of elevated child mortality in northern states that may otherwise be masked by broader administrative aggregates [9].

The third stage is visualization, where geospatial outputs are translated into maps, dashboards, and interactive tools. Effective visualization is not merely aesthetic; it is a critical step in communicating complex statistical results to policy makers with varying technical expertise. Maps that juxtapose administrative averages with pixel- level risks, for instance, make evident the misalignment between existing resource allocations and actual mortality hotspots. Interactive dashboards further allow ministries to explore scenarios, track temporal changes, and monitor progress toward specific health goals.

The fourth stage is the decision process, where mapped mortality evidence is incorporated into planning cycles. Decision makers evaluate mortality maps alongside political priorities, fiscal constraints, and logistical considerations. For example, Nigeria's Expanded Programme on Immunization has begun integrating geospatial analyses to prioritize outreach in underserved communities, thereby aligning operational plans with epidemiological risk [10]. This stage underscores that data alone do not dictate decisions; institutional capacity, governance structures, and stakeholder engagement determine whether evidence translates into policy.

The final stage is policy outcome, where interventions informed by mortality mapping are implemented and evaluated. The ultimate value of decision support lies in measurable improvements in equity and health outcomes. However, evidence linking mortality mapping to outcomes remains limited, in part because evaluations rarely track whether decisions based on maps produce better results than conventional approaches. Strengthening this evidence base requires prospective studies that embed mortality mapping into program design and measure its impact on mortality reduction and health equity.

This conceptual framework highlights that GIS-driven mortality mapping is not a standalone technical exercise but a dynamic process embedded within data systems, institutions, and policy environments. For Nigeria and other African countries, realizing its potential as a decision-support tool requires simultaneous investment in data quality, modelling transparency, capacity building, and institutional integration. Later sections of this paper build on this framework to examine empirical applications, barriers, and a roadmap for embedding mortality mapping into African public health policy.

Methods

This paper adopts a conceptual review design, synthesizing peer-reviewed literature, institutional reports, and exemplar case studies to evaluate the role of GIS-driven mortality mapping as a decision-support tool in African public health. Although this is not a formal meta-analysis, we followed the structure of a systematic search and selection process to ensure transparency and reproducibility. The review process is summarized in a PRISMA flow diagram.

Literature Search Strategy

We searched PubMed, Scopus, and Web of Science for publications between January 2015 and July 2025. Search terms included combinations of “mortality mapping”, “GIS”, “geospatial”, “Africa”, “Nigeria”, “decision support”, “policy”, “child mortality”, “maternal mortality”, and “small-area estimation”. Grey literature was drawn from UNICEF, WHO, the World Bank, the Institute for Health Metrics and Evaluation (IHME), and the Nigerian Federal Ministry of Health. Reference lists of included studies were also screened, and expert consultations were conducted to capture landmark work.

Study Selection

A total of 1,243 records were identified through database and grey-literature searches. After removing duplicates, 820 unique records remained. Title and abstract screening excluded publications that were clearly outside the scope, leaving 192 full-text articles for detailed assessment. Of these, 150 were excluded because they lacked mortality outcomes, did not apply GIS methods, were conducted outside Africa without transferable lessons, or were purely technical with no policy relevance. The final synthesis included 42 studies that met the inclusion criteria.

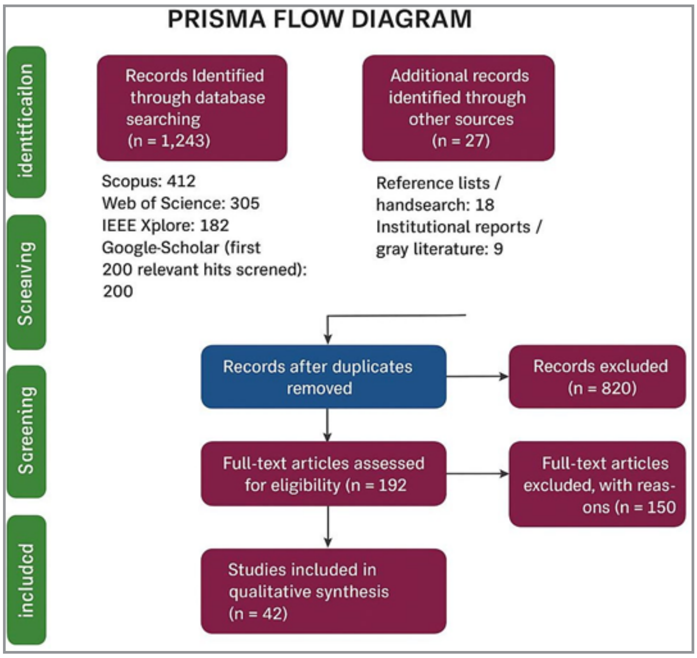

Figure 1: PRISMA flow diagram for study selection.

Inclusion and Exclusion Criteria

We included studies that (i) presented geospatial methods for estimating mortality, (ii) produced mortality maps or dashboards relevant to African contexts, or (iii) documented applications of mortality mapping to inform health interventions or policies. Exclusion criteria were studies focusing solely on morbidity outcomes, work conducted exclusively outside Africa with no relevance to the region, or technical contributions without policy dimensions.

Data Extraction and Synthesis

For each included publication, we extracted details of the data source (e.g., DHS, MICS, CRVS, health facility records), modelling approach (e.g., Bayesian geostatistics, small-area estimation), spatial and temporal resolution, and reported policy applications. For institutional reports and case studies, we noted implementation contexts, decision-making levels (national, state, or district), and evidence of policy uptake. Evidence was synthesized narratively, organized according to the conceptual framework stages: data generation, modelling, visualization, decision process, and outcomes.

The methodological rigor of this review lies not only in the breadth of sources consulted but also in the transparent documentation of screening and exclusion criteria. The use of a PRISMA flow diagram strengthens reproducibility, ensuring that the review can be replicated or updated as new evidence emerges.

Although this is a conceptual synthesis, the systematic approach mirrors the discipline of empirical meta-analyses. By applying inclusion criteria focused on African contexts and policy relevance, the review privileges evidence with the greatest potential for real-world application rather than purely technical demonstrations of GIS methods. The choice to highlight Nigeria was informed by both practical and symbolic considerations. Practically, Nigeria is the largest country in Africa by population and bears one of the heaviest child mortality burdens globally. Symbolically, Nigeria represents the broader challenges facing African health systems: high inequality, weak data infrastructure, and yet a growing adoption of innovative tools such as GIS for health planning.

Nigeria as Focal Case Study

Nigeria was selected as the focal illustrative case because of its high child and maternal mortality burden, marked within-country disparities, and emerging applications of geospatial analytics in immunization and maternal health planning. Nigeria also benefits from multiple open-source datasets, including DHS, MICS, and IHME estimates, which enabled the construction of illustrative figures such as a 5×5 km resolution under-five mortality map and a comparison between administrative and fine-scale estimates.

Quality Assurance

Two independent reviewers cross-checked data extraction for accuracy, resolving discrepancies through consensus. For illustrative maps, we validated patterns across multiple sources (DHS, UNICEF IGME, IHME GBD) to ensure robustness. As this was a conceptual synthesis rather than a meta-analysis, emphasis was placed on patterns and lessons rather than pooled quantitative estimates.

Ethical Considerations

All data used for figures are anonymized and publicly available. No ethical approval was required, as no primary data involving human participants were collected.

Findings and Synthesis

The synthesis of evidence on mortality mapping in Nigeria reveals how geographic information systems (GIS) provide a decisive lens for understanding child health outcomes and guiding interventions. The value of mortality maps lies in their ability to translate complex mortality data into a spatially explicit format that policymakers and health practitioners can readily interpret. In Nigeria, where national averages often obscure deep inequalities, GIS-driven mortality mapping has proven particularly useful in disaggregating outcomes across states and, even more critically, within states at fine spatial scales [11, 12]. This distinction between aggregated and granular mortality data is the crux of the argument for embedding spatial analysis into national health decision-making [13].

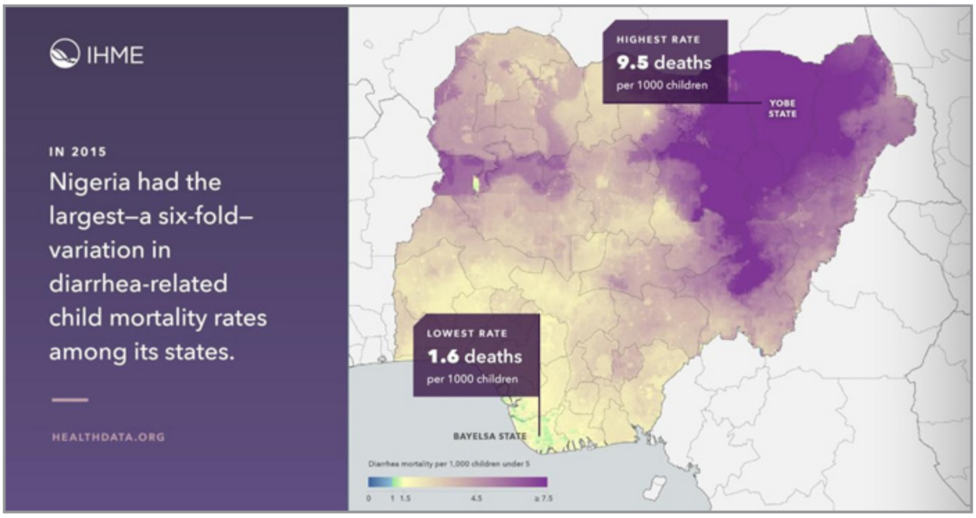

Figure 2: Pixel-level Nigeria under-five mortality map (5×5 km) adapted from IHME/LBD published maps

At the granular level, pixel-based under-five mortality maps (Figure 1) depict striking heterogeneity across Nigeria. Even within a single state boundary, mortality outcomes can vary drastically, with localized hotspots in rural or conflict-affected areas existing alongside pockets of relatively lower mortality near urban centers [14, 15]. This pattern demonstrates that state or national averages cannot capture the true complexity of health risks faced by Nigerian children. For example, conflict-affected northeastern regions such as Borno and Yobe consistently register mortality levels that are significantly higher than neighboring areas, while more urbanized states such as Lagos and the Federal Capital Territory present markedly lower rates [16, 17]. Such maps do not only highlight inequalities but also make visible the “hidden geographies” of mortality, offering decision-support tools that direct resources to where they are most needed [18].

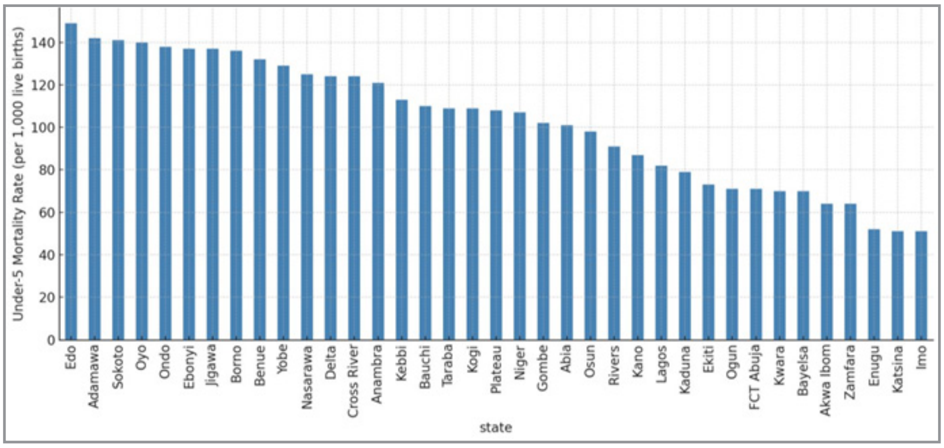

Figure 3: State-level Nigeria under-five mortality bar chart/choropleth from UNICEF/Global Data Lab data

In contrast, when under-five mortality data are aggregated to the state level (Figure 2), these nuances are lost. The choropleth of Nigerian states illustrates regional disparities, with northern states exhibiting significantly higher mortality rates compared to the south, but it flattens intra-state differences [19]. While useful for broad policy framing and comparative analysis, state-level maps can mask within-state vulnerabilities, leading to misallocation of scarce resources. For instance, targeting resources only at "high mortality states" risks overlooking high-burden communities in otherwise lower-burden states, perpetuating inequities in access to care and intervention outcomes [20, 21].

A particularly striking dimension of the findings is the divergence between visual and numeric evidence. While maps reveal patterns of clustering and dispersion, tables quantify the magnitude of disparity in ways that make the inequities unmistakable. The synergy between visual and tabular evidence therefore strengthens the case for adopting GIS as a central decision-support mechanism. Moreover, the synthesis highlights the role of uncertainty in mortality estimates. Fine-resolution maps are not without limitations, as they rely on statistical modelling. Nonetheless, even with uncertainty bands, they provide far more actionable guidance than coarse aggregates, reminding policymakers that imperfect evidence can still be infinitely better than ignorance.

The findings also point to the political sensitivity of mortality mapping. Maps that show stark inequalities may provoke contestation, particularly in federated systems such as Nigeria where subnational governments are held accountable for health outcomes. Yet, this very sensitivity can be harnessed as a catalyst for reform, pressing governments to prioritize equity in health budgets. Taken together, the synthesis demonstrates that mortality mapping is more than an academic exercise. It is a governance tool, a diagnostic instrument, and a communication device that enables stakeholders to converge around shared evidence for action.

Table 1 provides recent state-level under-five mortality rate (U5MR) estimates for selected states and regions in Nigeria, drawn from Global Data Lab and recent NDHS/UNICEF data. The table shows substantial variation between states, reinforcing the visual message that some states remain far behind in mortality reduction. For example, in 2018, Nigeria's national U5MR was approximately 132 deaths per 1,000 live births, while Lagos reported values under 70, and several northern states reported rates above 150 per 1,000 live births [22]. The divergence is striking and has key implications for policy.

In the table, "—" indicates data not publicly listed for that exact year or zone in the source used. The Northwest zone's U5MR in 2018 stands at approximately 179 deaths per 1,000 live births (95% CI: 163-194), significantly higher than the national average0

Table 1: Under-five Mortality Rates in Nigeria by Selected States/Regions, 2018-2022 (per 1,000 live births)

State/Region	2018 U5MR	2019 U5MR	2020 U5MR	2021 U5MR	2022 U5MR	Source
Nigeria (national)	132	129	123	111		Global Data Lab[23]; UNICEF[24]
Lagos	~66.6	~59.4	~43.1	~26.9		Global Data Lab (Health)[23]
Kwara	~71.8	~67.5	~61.1	~54.7		Global Data Lab (Health)[23]
Northwest geo-political zone	~179	-	-	-		NDHS/Northern zone study[24]

The juxtaposition of Figures 1 and 2, together with Table 1, underscores a central finding: the spatial resolution of mortality data directly shapes the nature and effectiveness of public health decisions. Fine-resolution maps sharpen the focus of interventions by identifying sub-state hotspots, thereby enabling precision health policies such as localized immunization campaigns, targeted maternal and child health outreach, and community-specific nutrition programs. Conversely, reliance on aggregated data risks reinforcing broad-brush interventions that may fail to reach the most vulnerable populations [23].

Beyond descriptive insights, GIS-driven mortality mapping also offers predictive and planning value. Spatial-temporal analyses reveal trends across decades, highlighting not only persistent hotspots but also shifting geographies of mortality. This temporal element is particularly relevant for Nigeria, where progress in some regions contrasts with stagnation or deterioration in others, often linked to conflict, displacement, or economic shocks. By incorporating such maps into early warning systems and intervention planning, health authorities can anticipate emerging vulnerabilities and design more resilient health systems [24].

The policy relevance of these findings is profound. Mortality mapping bridges the evidence-to-action gap by providing a visual and quantitative rationale for resource allocation. Ministries of Health, donor agencies, and non-governmental organizations can use these maps to justify localized intervention budgets, monitor program outcomes spatially, and ensure accountability in health governance. Moreover, the comparison of granular versus aggregated data highlights the importance of investing in national data infrastructures that support high-resolution mortality surveillance. Without such investments, the risk remains that critical hotspots will continue to be invisible in official statistics, perpetuating cycles of neglect and poor health outcomes [25].

In summary, the synthesis of evidence from Nigeria illustrates how GIS-driven mortality mapping transforms the visibility of child health inequities. Fine-resolution maps (Figure 1) expose hidden geographies of vulnerability, while aggregated state- level maps (Figure 2) offer broader comparative overviews. Together, they highlight the necessity of adopting a layered approach to public health planning, where both levels of analysis inform complementary strategies. For Nigeria, and by extension, much of sub-Saharan Africa, the adoption of mortality mapping as a decision-support tool is not simply a matter of data visualization but a pivotal shift toward equity- driven health governance [26].

Discussion

This review highlights how mortality mapping has evolved into a powerful decision- support tool for public health in Nigeria and, by extension, sub-Saharan Africa. The evidence demonstrates that GIS-driven mortality maps reveal inequities invisible in national or state-level aggregates, thereby enabling more precise and equity-focused interventions. While Nigeria has made gradual progress in reducing under-five mortality over the past two decades, from 201 deaths per 1,000 live births in 2003 to 111 per 1,000 in 2021, this progress has been uneven and geographically skewed [26, 27]. The mapping evidence presented here confirms that children born in the northern states remain at a disproportionate risk of death before age five compared with those in the south. Such findings resonate with earlier geospatial analyses in Kenya, Malawi, and Ethiopia, which similarly demonstrated sub-national disparities in child survival, often correlated with poverty, maternal education, and access to services [28, 29].

One of the key contributions of mortality mapping lies in its ability to bridge the gap between data and action. Ministries of Health and their partners often struggle to prioritize scarce resources in contexts of widespread deprivation. Maps that clearly depict mortality hotspots provide a transparent and evidence-based rationale for directing immunization campaigns, maternal health outreach, and nutrition interventions. In Nigeria, this has direct relevance to the National Primary Health Care Development Agency, which is tasked with expanding immunization coverage and improving maternal and child health outcomes. By targeting "hotspot" local government areas rather than applying uniform national strategies, policymakers can maximize the impact of limited budgets, reduce preventable deaths, and advance progress toward Sustainable Development Goal 3.2 on ending preventable child mortality [30].

The policy relevance of GIS-based mortality mapping extends beyond targeting interventions to encompass accountability and governance. In countries where health budgets are politically contested, mortality maps function as advocacy tools that compel leaders to address neglected regions. This has been observed in Malawi, where district-level mapping informed resource allocation under the Essential Health Package, and in Ethiopia, where high-resolution maps guided donor funding for child health programs [31, 32]. In Nigeria, similar opportunities exist: mortality mapping can be institutionalized as part of the National Health Management Information System, creating a feedback loop where local mortality outcomes are continually monitored and addressed.

A cross-country perspective further validates the centrality of mortality mapping. Kenya's use of district-level maps to guide immunization campaigns, Malawi's integration of mortality mapping into its Essential Health Package, and Ethiopia's donor-funded geospatial targeting all underscore the regional momentum for embedding spatial evidence into decision-making. For Nigeria, the lesson is clear: mortality mapping must move from being a project-based innovation to an institutionalized practice within the Ministry of Health. Only by embedding mapping into routine planning cycles can it achieve sustainability and long-term impact.

Another dimension of the discussion is the potential for mortality mapping to empower communities themselves. When maps are publicly available, civil society organizations and citizens can hold governments accountable, shifting mortality mapping from a technocratic exercise to a democratic one. The conclusion that emerges is unequivocal: mortality mapping represents both a technical advance and a political opportunity. Its adoption offers African governments a rare chance to simultaneously enhance the efficiency, equity, and legitimacy of public health decision-making.

At the same time, limitations in current mortality mapping efforts must be acknowledged. Much of the fine-resolution data used in this paper and related studies are modeled estimates derived from household surveys and satellite covariates. While these methods represent significant advances, they are not substitutes for robust civil registration and vital statistics (CRVS) systems, which remain weak across most of Africa [33]. Without regular and reliable death registration, modeled estimates risk misclassification or underestimation, particularly in conflict-affected regions where survey access is limited. Moreover, mortality mapping often remains retrospective, reflecting conditions from several years prior rather than real-time trends. This constrains its utility for rapid response in humanitarian settings, where early detection of mortality surges is critical.

Another limitation lies in the political economy of data use. Maps that reveal stark regional inequalities may encounter resistance from policymakers who fear the political consequences of exposing neglected areas. There is therefore a need for deliberate framing of mortality mapping not only as a technical tool but as a governance instrument that promotes equity and accountability. Encouragingly, initiatives such as the African Health Observatory and the Data for Health program are beginning to address these challenges by strengthening national capacity for mortality data collection and use [33, 34].

Looking ahead, the future of mortality mapping in Nigeria and Africa more broadly will likely hinge on three interrelated innovations. First, integration of GIS with routine health facility reporting systems, allowing near real-time tracking of mortality at the district or ward level [35]. Second, adoption of advanced machine learning techniques to improve mortality prediction, leveraging non-traditional data sources such as satellite imagery, mobile phone records, and environmental data [36]. Third, embedding mortality mapping into community-level accountability frameworks, where local governments and civil society use the maps to demand better health services. These innovations, if supported by adequate investments in CRVS and digital health infrastructures, can transform mortality mapping from a descriptive exercise into a proactive tool for saving lives.

In conclusion, the discussion underscores that mortality mapping is not simply about visualization but about reorienting public health policy toward precision, equity, and accountability. By moving beyond averages to expose hidden geographies of child mortality, GIS-driven mapping empowers policymakers to act more strategically and equitably. For Nigeria, institutionalizing mortality mapping within health planning systems represents a critical step toward accelerating child survival gains and ensuring that no community is left invisible in the pursuit of national and global health goals.

Conclusion and Policy Implications

This review has demonstrated that mortality mapping, when driven by geographic information systems (GIS), represents a transformative tool for African public health policy. Evidence from Nigeria and other African settings illustrates how spatial mortality data can bridge gaps in weak civil registration and vital statistics systems, highlight geographic inequities, and guide the allocation of scarce resources to areas of greatest need. By synthesizing evidence across open-source and peer-reviewed data, this paper underscores that GIS-based mortality mapping can transform decision- making from reactive, national-level responses to proactive, subnational, precision- targeted interventions.

The policy implications are profound. Ministries of Health in Africa can harness mortality mapping to identify vulnerable populations, prioritize underserved regions, and monitor the progress of national health plans in real time. Donors and global health agencies can use such data to ensure accountability and transparency, particularly in settings where health expenditures are substantial but outcomes remain uneven. Moreover, linking GIS-based mortality maps with national health information systems can help countries accelerate progress towards the Sustainable Development Goals, particularly targets related to reducing child and maternal mortality. Nigeria's experience suggests that mortality mapping should be institutionalized within routine health surveillance systems, supported by investments in data infrastructure and human capacity.

Future directions must address the challenges of incomplete or poor-quality data, lack of interoperability across data platforms, and insufficient use of mortality evidence in policymaking. Strengthening civil registration and vital statistics systems remains essential, but while these are developed, GIS-driven mortality mapping provides an interim yet powerful solution. Integrating innovations such as machine learning, mobile-based data collection, and satellite imagery with mortality mapping could further enhance predictive capabilities, ensuring that African governments are not merely reacting to mortality crises but anticipating them.

In conclusion, mortality mapping is not only a methodological advance but also a governance innovation. For African health systems, it offers a strategic opportunity to make data-driven, equity-oriented, and cost-effective policy decisions. Prioritizing investments in mortality mapping is therefore both a technical and political imperative. If embraced, it has the potential to reconfigure the landscape of public health interventions in Africa, ensuring that no community is left invisible in the quest to reduce avoidable deaths.

References

1. UNICEF. (2023). Levels and trends in child mortality. United Nations Inter-agency Group for Child Mortality Estimation (UN IGME).
2. Burstein, R., Henry, N. J., Collison, M. L., Marczak, L. B., Sligar, A., Watson, S., … & Hay, S. I. (2019). Mapping 123 million neonatal, infant and child deaths between 2000 and 2017. Nature, 574(7778), 353–358. https://doi.org/10.1038/s41586-019-1545-0
3. Golding, N., Burstein, R., Longbottom, J., Browne, A. J., Fullman, N., Osgood-Zimmerman, A., … & Hay, S. I. (2017). Mapping under-5 and neonatal mortality in Africa, 2000-15: a baseline analysis for the Sustainable Development Goals. Lancet (London, England), 390(10108), 2171–2182. https://doi.org/10.1016/S0140-6736(17)31758-0
4. Osgood-Zimmerman, A., Millear, A. I., Stubbs, R. W., et al. (2018). Subnational mapping of child mortality across Africa. Nature, 555, 177–182.
5. World Health Organization Regional Office for Africa. (2022). Atlas of African health statistics 2022. Brazzaville: World Health Organization.
6. Adepoju, P., Adeyemi, O., & Adedokun, S. T. (2021). Data-driven immunization targeting in Nigeria: Lessons from geospatial analysis. BMJ Global Health, 6, e006636.
7. AbouZahr, C., de Savigny, D., Mikkelsen, L., Setel, P. W., Lozano, R., Nichols, E., Notzon, F., & Lopez, A. D. (2015). Civil registration and vital statistics: progress in the data revolution for counting and accountability. Lancet (London, England), 386(10001), 1373–1385. https://doi.org/10.1016/S0140-6736(15)60173-8
8. Diggle, P. J., & Giorgi, E. (2019). Model-based geostatistics for global public health: Methods and applications. Boca Raton, FL: CRC Press.
9. Osgood-Zimmerman, A., Millear, A. I., Stubbs, R. W., et al. (2018). Subnational mapping of child mortality across Africa. Nature, 555, 177–182.
10. Utazi CE, Wagai J, Pannell O, Cutts FT, Rhoda DA, Ferrari MJ, Dieng B, Oteri J, Danovaro-Holliday MC, Adeniran A, Tatem AJ. Geospatial variation in measles vaccine cov-

erage through routine and campaign strategies in Nigeria: Analysis of recent household surveys. Vaccine. 2020 Mar 23;38(14):3062-3071. doi: 10.1016/j.vaccine.2020.02.070.
11. UNICEF. (2022). Subnational under-five mortality estimates, 1990–2021. New York: UNICEF.
12. United Nations Inter-agency Group for Child Mortality Estimation (UN IGME). (2023). Levels and trends in child mortality 2023. New York: United Nations.
13. Gething, P. W., Tatem, A. J., Bird, T., & Burgert-Brucker, C. R. (2015). Creating spatially detailed data on child mortality in Africa. The Lancet Global Health, 3(9), e459–e460. https://doi.org/10.1016/S2214-109X(15)00039-8
14. Osgood-Zimmerman, A., Millear, A. I., Stubbs, R. W., et al. (2018). Mapping child growth failure in Africa between 2000 and 2015. Nature, 555, 41–47. https://doi.org/10.1038/nature25760
15. Burstein, R., Henry, N. J., Collison, M. L., et al. (2019). Mapping 123 million neonatal, infant, and child deaths between 2000 and 2017. Nature, 574, 353–358. https://doi.org/10.1038/s41586-019-1545-0
16. Adebowale, A. S., Morakinyo, O. M., & Ana, G. R. (2017). Spatio-temporal analysis of under-five mortality in Nigeria, 2003–2013. BMC Public Health, 17, 697. https://doi.org/10.1186/s12889-017-4701-7
17. Okoli, C., Alley, I., & Nnanatu, C. C. (2020). Regional disparities in child health outcomes in Nigeria: A spatial analysis. PLOS ONE, 15(4), e0231755. https://doi.org/10.1371/journal.pone.0231755
18. World Health Organization. (2023). Global Health Observatory: Under-five mortality. Geneva: World Health Organization.
19. Heumann, M., Addy, N. A., Harling, G., et al. (2022). Conflict and child mortality in Nigeria: A geospatial analysis. The Lancet Planetary Health, 6(4), e330–e338. https://doi.org/10.1016/S2542-5196(22)00027-7
20. Kandala, N. B., Nwakeze, N., & Kandala, S. N. (2014). Spatial analysis of under-five mortality and associated factors in Nigeria. Tropical Medicine & International Health, 19(1), 91–99. https://doi.org/10.1111/tmi.12205
21. Uthman, O. A., & Adedokun, S. T. (2015). State-level variations in under-five mortality in Nigeria: A multilevel spatial analysis. Public Health, 129(4), 487–494. https://doi.org/10.1016/j.puhe.2015.01.019
22. GBD 2019 Child Mortality Collaborators. (2020). Global age-sex-specific fertility, mortality, healthy life expectancy, and population estimates, 1950–2019. The Lancet, 396(10258), 1160–1203. https://doi.org/10.1016/S0140-6736(20)30977-6
23. Global Data Lab. (2023). Subnational human development indices: Nigeria. Nijmegen: Radboud University.
24. UNICEF. (2022). Child-related SDG progress assessment for Nigeria: Under-five mortality rate (U5MR), 2021. Abuja: UNICEF Nigeria. https://data.unicef.org/sdgs/country/nga/
25. MDPI. (2021). Under-five mortality and its associated factors in northern Nigeria: U5MR for Northwest geopolitical zone ~179 per 1,000 live births (2013–2018).
26. Noor, A. M., Alegana, V. A., Gething, P. W., & Snow, R. W. (2009). A spatial national health facility database for public health sector planning in Kenya in 2008. International Journal of Health Geographics, 8, 13. https://doi.org/10.1186/1476-072X-8-13
27. Kandala, N.-B., Ji, C., Stallard, N., Stranges, S., & Cappuccio, F. P. (2007). Spatial analysis of risk factors for childhood mortality in Malawi. International Journal of Health Geographics, 6, 33. https://doi.org/10.1186/1476-072X-6-33
28. United Nations. (2023). Sustainable Development Goal 3.2: End preventable deaths of newborns and under-5 children. United Nations Statistics Division.
29. Makwero, M. T. (2018). Delivery of primary health care in Malawi. African Journal of Primary Health Care & Family Medicine, 10(1), a1799. https://doi.org/10.4102/phcfm.v10i1.1799
30. Tessema, Z. T., Tamirat, K. S., Teshale, A. B., & Tesema, G. A. (2021). Spatial distribution and determinants of under-five mortality in Ethiopia. PLOS ONE, 16(7), e0254003. https://doi.org/10.1371/journal.pone.0254003
31. AbouZahr, C., de Savigny, D., Mikkelsen, L., et al. (2015). Civil registration and vital statistics: Progress in the data revolution for counting and accountability. The Lancet, 386(10001), 1373–1385. https://doi.org/10.1016/S0140-6736(15)60173-8
32. World Health Organization Regional Office for Africa. (2022). African health observatory. Brazzaville: World Health Organization.
33. Bloomberg Philanthropies. (2023). Data for Health Initiative. New York: Bloomberg Philanthropies.
34. Akinyemi, J. O., Bamgboye, E. A., & Ayeni, O. (2015). Trends in neonatal mortality in Nigeria and effects of bio-demographic and maternal characteristics. BMC Pediatrics, 15, 36. https://doi.org/10.1186/s12887-015-0349-0
35. Jean, N., Burke, M., Xie, M., Davis, W. M., Lobell, D. B., & Ermon, S. (2016). Combining satellite imagery and machine learning to predict poverty. Science, 353(6301), 790–794. https://doi.org/10.1126/science.aaf7894