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Study protocol for developing an integrated urban health data portal to strengthen urban health systems in Nepal

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Abstract

Urban populations in low- and middle-income countries (LMICs) are growing rapidly, bringing diverse socio-economic groups, extensive informal settlements, and frequent migration into cities. Local governments in cities are central to policies and programmes to protect and improve the health of their urban populations. Yet, many struggle to access, integrate and utilise data across the multiple sectors that influence health, plurality of health providers and to do this at a granular spatial level that supports local decision making. These trends have led to persistent health challenges and stark disparities in access to care and health outcomes, as resource allocation and planning often lag behind dynamic urban need. This protocol describes a mixed-methods implementation study in two wards of Budhanilkantha municipality of Nepal to assess existing municipal data systems, collect geospatial data and household data, and build an integrated urban health data portal. We will conduct stakeholder interviews and policy reviews to understand data use and gaps. We will then carry out social mapping, a door-to-door household census, and health facility assessments to generate detailed ward-level data on population, infrastructure, and health care services. These data will be geocoded and linked via common identifiers to existing routine health and administrative databases. We will co-create an interactive portal with local government users, featuring real-time dashboards, GIS maps, and analytic tools to support local planning and equity-focused decision-making. The expected outcome is a proof-of-concept framework showing how combined routine and primary data can inform resilient, multisectoral urban health governance.

Keywords Urban health, Data hub, Health system, Nepal

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1 Introduction

Rapid urbanization is one of the defining trends of the 21st century, especially in low- and middle-income countries (LMICs) [1]. The United Nations projects that by 2050 nearly 68% of the world's population will live in urban areas, with most growth occurring in South Asia and Africa [1]. While cities can offer economic opportunities and access to services, unplanned growth often outpaces infrastructure, leading to slums and informal settlements with poor living conditions [1, 2]. In Nepal and similar settings, municipal planning structures face new pressures: heterogeneous populations, mobile labor forces, complex social dynamics and the impact of non-health sectors such as transport, housing, planning on population health and well-being [3, 4]. These factors contribute to urban health challenges such as overcrowding, environmental hazards, infectious disease transmission, and rising communicable and non-communicable diseases [2, 5]. Critically, rapid change can exacerbate inequalities: marginalized groups (the urban poor, migrants, women, and ethnic minorities) often experience limited access to health care and worse outcomes compared to wealthier residents [2, 4, 5]. Rapid migration swells cities, pushing rural and cross-border migrants into informal settlements with little planning. Informal settlements, often invisible in official records, face overlapping deficits- unsafe housing, poor sanitation, no clean water, inadequate services, and unpaved roads- while also bearing environmental hazards like flooding, waste pollution, and air contamination. Such clustered risks drive diarrheal disease, mosquito-borne infections, and respiratory illness, yet without detailed local data, municipalities cannot target resources or improve urban health [6, 7].

Despite the acute need, robust data on urban health status and the determinants that influence health in LMIC settings are often lacking. Routine health information systems (e.g. clinic records, vital registration) are usually designed for national or rural contexts and rarely cover the plurality of providers within urban areas or capture the granularity needed at city or ward levels. They may omit informal settlements entirely or fail to disaggregate by socio-economic status and migration status [8]. At the same time, periodic surveys (e.g. Demographic Health Survey, household surveys) provide snapshots but are infrequent and may not cover slum areas and urban issues adequately [2, 3, 8, 9]. Furthermore, ward-level or community-level data are scarce. This lack of granuality undermines equity-focused planning, as it obscures where health needs are greatest. For example, a slum cluster in one ward might have high child mortality or lack safe water, but without ward-level data these problems remain "hidden" in aggregate urban statistics [2, 8].

Data fragmentation is a final, critical challenge. Planners and health managers frequently work with fragmented information: different sectors such as health, education, water, maintain separate databases with no interoperability. Health, census, urban planning and utility data are often held in silos or updated infrequently, so city officials cannot link data to understand the wider risks to health or to identify system bottlenecks [7, 10]. In many LMICs, multiple agencies collect diverse and potentially valuable information on for example, clinic visits, vital events, migration estimates, but the differing formats or geographical coverage undermine interoperability. A recent review found that a major barrier to effective use of health data for planning, monitoring, and improving service delivery is data fragmentation, where different databases use inconsistent coding and formats [7, 10, 11]. Likewise, a multi-city study of health information systems

noted the data quality and interoperability of various separate systems as the greatest challenges [10, 11]. Fragmented data mean municipalities lack a coherent evidence base with maps of disease incidence, population density and sanitation rarely overlapping, so planning immunization campaigns or new clinics can miss the neediest areas.

The rationale for an integrated urban health data approach is to create a comprehensive, interoperable information system that combines all relevant data for local action. Linking routine administrative data with new primary data collection, we can develop detailed community profiles and dynamic monitoring tools. Such a system can support evidence-informed decision-making by municipal authorities, health officials, and civil society, enabling timely responses to emerging issues and addressing inequities. In this model, data become a shared public good rather than siloed departmental assets.

This study aims to design, implement, and document an integrated urban health data portal in a selected municipality of Nepal. Specifically, we will: assess existing municipal data sources and systems to identify gaps and limitations; conduct social mapping to measure and map key health and socio-demographic indicators at the ward level; carry out a complete household census to capture urban health issues, complemented by health facility assessments in two wards of municipality to address data gaps; and develop an interactive dashboard and GIS platform that integrates routine and newly collected data, enabling real-time visualization and analysis to support evidence-based local planning. These wards have diverse populations, including dense informal settlements and migratory populations, and are manageable for intensive fieldwork. Lessons learned will inform broader rollout to other wards and cities in Nepal and similar LMIC contexts.

2 Materials and methods

2.1 Study design

This mixed-methods implementation study will be conducted in two wards of Budhanilkantha Municipality, Kathmandu, using qualitative methods and primary quantitative data collected from the selected wards. Secondary data from routine municipal data systems will also be used. A pragmatic approach will be adopted to understand and improve urban health data systems within the local context. The study will be implemented in three sequential phases: (1) stakeholder engagement and formative research, including household census and social mapping, conducted from March to November 2025; (2) technical development of the Urban Health Data Portal, including data integration, validation, and visualization, conducted from November 2025 to June 2026; and (3) implementation and institutional embedding of the portal, including user engagement, capacity strengthening, and integration into municipal data management and decision-making processes, planned from July to December 2026.

2.2 Study setting

Budhanilkantha Municipality has a diverse and rapidly changing urban population and provides a range of municipal and public services relevant to urban health. It was purposively selected based on its relevance to the development and implementation of the Urban Health Data Portal. The municipality provided a suitable setting for examining data generated across different municipal sectors and assessing its potential for integration into the Urban Health Data Portal.

2.3 Formative research

We will conduct a range of activities to gather insights before designing the data collection tools:

- **Stakeholder interviews**: Key informant interviews will be conducted among municipal officials using purposive sampling to ensure representation from departments and sectors that generate, manage, or use data relevant to the Urban Health Data Portal, including Health, Education, Civil Registration, Disaster Management, Animal Health, Agriculture, Environment, Infrastructure, Information Technology (IT), and Women, Children and Inclusion. Approximately 12 participants will be identified in collaboration with municipal authorities and project partners based on their involvement in generating, managing, reporting, accessing, or using relevant data. Semi-structured interviews will explore existing data sources and workflows, priority urban health issues, data access and use, opportunities for integration into the Urban Health Data Portal, and barriers to data sharing and use. Interviews will be conducted in Nepali by trained researchers at a mutually convenient location, audio-recorded with written informed consent, and transcribed verbatim. Data will be analyzed thematically using a coding framework developed deductively from the study objectives and interview guide and refined inductively as new concepts emerge. Two researchers will independently code an initial subset of transcripts, resolve discrepancies through discussion, and apply the agreed framework to the remaining transcripts. NVivo will be used to support data management and coding.
- **Policy and document review**: Municipal plans, health policies, census reports, and previous survey findings will be reviewed to identify what data exist at ward/municipality level and any official strategies for urban health.

These formative activities will map the "information ecosystem" and guide the design of data collection instruments. They will enhance established relationships and buy-in with local stakeholders, which is crucial for co-creation of the portal and for ensuring data will be used in future. We will compile an inventory of data sources currently accessible to the municipality:

- **Routine data**: This includes the national health information system (e.g. Health Management Information System), civil registration system and municipal education records (school enrollment, attendance). We will request aggregate data at the ward level if available.
- **Non-routine data**: Past survey or research data (if any), program evaluations (e.g. NGO-led health projects), and any GIS layers (roads, utilities, administrative boundaries).

Based on the findings of the formative assessment and in agreement with the municipal team, we will identify key routine and non-routine data sources and assess their suitability to be integrated into the urban health data portal. We will identify key limitations, such as fragmentation across departments, lack of geolocation for data points, and absence of data on vulnerable subpopulations (e.g. migrants, urban poor). We will integrate routine municipal data from each department into the portal. Routine data sources include health facility records, vital registration (births and deaths), waste management,

water supply, education, and infrastructure databases. These datasets will be inventoried and standardized to ensure consistency in formats, variable names, and indicator definitions. Paper-based records will be digitized where necessary, with data cleaning and validation to improve quality. Automated data pipelines through APIs or periodic batch uploads will transfer routine data into the portal on a regular schedule (e.g. monthly or quarterly).

2.4 Primary data collection

Routine municipal information systems in Nepal, such as the Health Management Information System, civil registration, and administrative records, will provide essential but incomplete data for local planning. These datasets are expected to lack ward-level granularity, omit informal settlements, and fail to capture key household, environmental, and service readiness indicators. During the formative phase, municipal officials are anticipated to identify these data gaps as a major barrier to evidence-based and equitable planning. To address this, primary data collection including social mapping, a comprehensive household census, and a public health facility assessment will be conducted as a one-time, strategic investment to generate a detailed baseline for integration with routine data sources. These activities will be co-designed with local government users to ensure that the tools, indicators, and outputs directly address their information needs and strengthen institutional capacity for data use. While such data collection may entail higher initial costs and logistical demands, it will be essential to fill critical gaps left by routine systems, validate existing data, and reinforce local data ecosystems. The integration of these primary datasets with routine municipal information within a unified urban health data portal is intended to provide immediate utility while strengthening the long-term sustainability of the data system. As routine data systems are strengthened, the portal will increasingly rely on continuous data flows from municipal departments, transitioning from intensive primary data generation toward a sustainable, routine-driven data maintenance model that supports equity-focused decision-making. Therefore, we will conduct three interlinked primary data collection activities in two wards of municipality: social mapping, a household census, and a public health facility assessment.

2.5 Social mapping

We will use GIS-based social mapping to create detailed maps of two wards of the Budhanilkantha municipality which were selected by the municipal authorities as they represent a mix of low- and middle-income areas, including both planned neighborhoods and informal settlements. Based on discussions with the municipality team, agreed health risk indicators guided the mapping process. Community members participating in the social mapping will be identified in consultation with the municipality and respective ward offices. Ward officials will help identify appropriate local representatives who have knowledge of the local settlement structure, services, infrastructure, and environmental conditions. Local community members including youth volunteers, ward officials, will work with the research team to sketch ward boundaries and key landmarks on large printouts or digital map platforms. Locations of both public and private health providers and infrastructure (such as hospitals, health posts, basic health care center, NGO clinics, pharmacies), water sources (wells, taps), education facilities (schools, colleges), markets, transportation routes, and high-risk areas (garbage dumps, flood zones) will be marked.

Informal settlements, densely populated clusters, open spaces, green spaces, and blue spaces will also be delineated, along with shops selling meat, tobacco sales and liquor as these locations are relevant to understanding environmental health risks, food safety, and behavioral health determinants within the wards. Social mapping will feed into the urban health data portal by visually pinpointing underserved areas, clustering of health risks, and environmental hazards at the ward level. Using the community knowledge with geotagged data, it will create interactive GIS layers that allow users to compare wards, track changes, and overlay health, infrastructure, and environmental indicators making gaps clear and guiding evidence-based local planning.

2.6 Household census

Household census data will provide detailed information on population characteristics, health, socioeconomic conditions, and environmental factors that can contribute to the Urban Health Data Portal. This granular insight enables targeted, evidence-based interventions by highlighting vulnerable groups, service gaps, and environmental risks. When geotagged and integrated, household data transforms into powerful maps that pinpoint hotspots and track changes over time, driving smarter resource allocation and timely responses. Beyond data, it empowers communities and health workers by making health information transparent and actionable, ultimately fueling healthier, more equitable urban futures. With this importance, the household census will be conducted among household heads, mothers of children under two, and all family members in two wards of the municipality. The quantitative target will be to enumerate all households identified in Wards 4 and 7 through household listing and social mapping, with all eligible household members included according to the relevant questionnaire module. We will also adopt a citizen science approach by involving local residents in data collection and fieldwork, which improved data accuracy through their local knowledge and enhanced community understanding of the research process. Household heads or the most knowledgeable members will provide data on household composition, socio-demographics, assets, mortality, healthcare access, environmental conditions, and waste management. Adults aged 18 and above will report on risk behaviors, including tobacco and alcohol use, diet, physical activity, and the prevalence of communicable and non-communicable diseases. Mothers of young children will provide information on maternal health, antenatal and postnatal care, child immunization, and HPV vaccination coverage among adolescent girls aged 10–19 years, who also self-reported on HPV vaccination status. Household members involved in agriculture or livestock will provide details on land use and livestock ownership. Anthropometric measurements- height, weight, BMI, and blood pressure will be recorded for all adults present, while mid-upper arm circumference assessed nutritional status in children under five years. The questionnaire will be developed in Nepali, pretested in a similar setting, and refined accordingly. Field enumerators will use tablets with electronic data entry forms (e.g., Open Data Kit) to minimize errors and enable daily uploads to a secure database. A physical "family health folder" with a unique ID, summarizing key health indicators, will be printed for each household to engage families and support local health staff in monitoring. Data quality will ensure through daily reviews, GPS tracking of enumerator routes, and random spot-checks by supervisors. The household census provides ward-level population data and identifies community-level patterns such as clusters of vulnerability. We will identify the

key indicators from the census that will be integrated into the Urban Health Data Portal (see Table 1).

Quantitative data from the household census and facility survey will be analyzed to compute descriptive statistics (demographic profiles, prevalence of key health and socio-economic indicators). We will use GIS analysis to identify spatial patterns (e.g. clustering of poverty, distance to health services). The integrated portal itself will serve as a living analysis tool, allowing users to generate tables and charts in real time. We will conduct a preliminary evaluation of the portal's usability (e.g. through user acceptance testing with municipal staff) and document any implementation challenges.

2.7 Health facility assessment

Health facility data will provide information on service availability, staffing, equipment, medicines, and service readiness relevant to assessing health-system capacity. This integration will inform targeted interventions to improve health service coverage and equity in the municipality. They provide crucial insights into service availability, staffing, equipment, and medicine stocks highlighting where resources meet needs and where gaps persist. Understanding patient flow and utilization patterns further reveals emerging health trends and demand spikes, supporting timely, data-driven interventions.

In response to the municipality's growing demand for evidence-based planning and equitable health service delivery, we will conduct a comprehensive assessment of all public health facilities serving Wards 4 and 7 of Budhanilkantha Municipality. Public facilities are prioritized because they represent the primary access point for essential health services for the majority of residents particularly low-income and marginalized groups and their performance directly reflects municipal accountability for health outcomes. The assessment will cover 11 public facilities, including one public hospital, six health posts and four basic health service centers.

Data will be collected using the structured assessment tools developed for this study to capture detailed information on facility infrastructure, service readiness, equipment,

Table 1 List of key indicators from household census that can be integrated into urban health data portal

Section	Indicators
Socio-Demographic Data	Household composition (age, gender, education, employment, family structure) Socio-economic status and assets
Health Status and Disease Data	Prevalence of communicable and non-communicable diseases (NCDs) Maternal health indicators (antenatal, postnatal care) Child health indicators (immunization status, including HPV vaccination) Health-seeking behaviors and access to healthcare facilities
Risk Behaviors and Lifestyle Data	Tobacco and alcohol use Dietary habits and physical activity levels Sedentary behavior
Environmental Health Data	Sanitation and waste management practices Exposure to air pollution Housing quality and access to safe drinking water
Anthropometric and Clinical Measurements	Height, weight, BMI of household members Blood pressure readings for adults Mid-upper arm circumference (MUAC) for children under five
Geospatial Data	Household locations linked to ward boundaries Clusters of informal settlements and densely populated areas
Agriculture and Livestock Data	Land use for agriculture Livestock and poultry ownership and business activities

and logistics. The survey will also assess the availability of 18 tracer drugs and collect data on health care providers, including their education, years of experience, and training received. Additionally, secondary data from Nepal's Minimum Service Standards (MSS), a nationally endorsed framework of the Ministry of Health and Population will be used to benchmark performance across domains such as human resources, infrastructure, and service delivery capacity.

GPS coordinates of each facility will be captured to support spatial analysis. Facility data will be linked with household census data using GIS and patient flow information to identify service gaps relative to community health needs and geographic distribution.

2.8 Data management and security

A structured data management plan will be implemented to ensure the quality, security, confidentiality, and integrity of all study data. Data collected through household surveys, health facility assessments, social mapping, and secondary data sources will be stored in secure, password-protected systems, with access restricted to the designated municipal focal person and authorized study team members, as appropriate. Regular data backups and standardized file management procedures will be maintained. Data will undergo routine quality checks to identify missing, duplicate, inconsistent, and out-of-range values, and data cleaning procedures will be documented. Where data from multiple sources are linked, unique study identifiers and standardized administrative codes will be used, and personally identifiable information will be separated from analytical datasets where feasible. Geospatial information that could identify individual households will be appropriately protected and will not be publicly displayed at an identifiable level. Final cleaned datasets and relevant documentation will be securely archived in accordance with institutional and ethical requirements, with access restricted to the designated municipal focal person and other authorized personnel.

2.9 Quantitative data management and analysis

Key variables and indicators to be extracted from each data source will include demographic and socioeconomic characteristics, health status and disease indicators, maternal and child health indicators, health-seeking behavior, risk behaviors, environmental health indicators, health facility readiness, routine health service utilization, vital statistics, social inclusion and vulnerability indicators, and relevant geospatial information. The specific variables and indicators to be extracted from each data source are summarized in Table 2.

Table 2 summarizes the data sources and key variables and indicators that will be used to develop the Integrated Urban Health Data Portal. The data sources provide complementary information needed to generate a comprehensive understanding of urban health, population characteristics, environmental conditions, and health service delivery in Nepal. The Household Census provides detailed demographic, socioeconomic, health, and housing information, forming the foundational dataset for constructing population and health indicators. Social mapping provides spatial information on settlements, services, and environmental risks at the ward level. The Health Facility Assessment provides systematic information on service availability, infrastructure, and facility readiness. Routine health information from HMIS/DHIS2 provides data on maternal and child health, disease burden, and service utilization trends. Civil Registration/Vital Events provides

Table 2 Data sources included in the development of the urban health data system

Data Source	Type of Data	Key Variables/Indicators to be Extracted	Frequency	Purpose in the Study	Expected Output
Household Census	Primary household-level demographic, socioeconomic, and housing data	Household composition, age, sex, education, employment, SES/assets, health status, maternal and child health, health-seeking behavior, risk behaviors, environmental health, anthropometric measures	Periodic	To obtain baseline information on population, housing, and SES	Base dataset for indicator construction
Social Mapping	Spatial data on settlements, services, and environmental risks	Settlement/household locations, health facilities, services, environmental hazards, informal settlements, densely populated areas	Periodic	To map community structure, service distribution, and hazards	Ward-level spatial layers
Health Facility Assessment	Facility readiness, service delivery, infrastructure	Facility type, staffing, infrastructure, equipment, medicines, service availability, readiness indicators	Periodic	To assess availability, readiness, and quality of health services	Facility readiness index
HMIS/DHIS2	Routine health service data	Maternal and child health, NCDs, communicable diseases, service utilization, morbidity and mortality indicators	Monthly	To extract key health indicators and service utilization trends	Health service indicator set
Municipal Records	Administrative and program data	Municipal services, programs, planning, governance, and relevant administrative indicators	Continuous	To understand municipal service delivery, planning, and governance	Municipal administrative profiles
Civil Registration/Vital Events	Birth, marriage, and death registration	Births, deaths, marriages, and related vital statistics	Continuous	To incorporate vital statistics into municipal demographic and health profiles	Birth rate, death rate, marriage statistics
Women, Children, and Social Inclusion	Disability, single mothers, vulnerable households, and inclusion indicators	Disability, single mothers, vulnerable households, and relevant social inclusion indicators	Periodic	To integrate social inclusion and vulnerability characteristics	Disability indicators, vulnerable household profiles
Municipal Records	Administrative and program data	Water, sanitation, waste management, environmental management, and other relevant municipal environmental indicators	Continuous	To understand environmental issues, map environmental risks and hazards, and assess their spatial distribution.	Environment related indicators.

information on births, deaths, and marriages, while Women, Children, and Social Inclusion data provide information on disability, single mothers, vulnerable households, and other inclusion-related characteristics. Municipal records provide administrative and programmatic information to contextualize local governance, planning, and service delivery.

Quantitative data from the household census and health facility assessment will be analyzed using appropriate descriptive statistical methods. Indicators will be constructed using predefined operational definitions, with numerators and denominators specified for each indicator where applicable. The analysis will summarize household

demographic and socioeconomic characteristics, health indicators, environmental conditions, housing and living conditions, and health service accessibility and utilization. Indicators will be aggregated to the ward level and disaggregated by relevant characteristics, including sex, age group, geography, and thematic domains. Before analysis, datasets will undergo data quality checks to identify duplicate records, missing values, inconsistent responses, and out-of-range values. Standardized data extraction and data management procedures will be applied across data sources to ensure consistency in variable definitions, reporting periods, and levels of disaggregation. GIS-enabled spatial analyses will be conducted to visualize the distribution of health facilities, environmental hazards, infrastructure, and population characteristics across the study wards. Spatial layers generated through participatory social mapping will be integrated into the Urban Health Data Portal to support visualization of service availability, environmental risks, and population vulnerability patterns. Because the household census will be conducted only in Wards 4 and 7, demographic and housing characteristics for the remaining municipal wards will be compiled from the National Population and Housing Census 2021 to support municipality-wide demographic and housing profiles and comparative visualization across wards. Together, these datasets will enable the Urban Health Data Portal to integrate demographic, health, spatial, administrative, environmental, and social inclusion information, supporting municipalities to plan, monitor, and improve urban health services using locally relevant and evidence-based information.

2.10 Data integration and portal development

The final phase focuses on integrating all collected data and developing the Urban Health Data Portal framework. Existing administrative and spatial datasets, including ward boundaries and the locations of key landmarks such as health facilities, schools, roads, and other public infrastructure, will be used as the primary spatial reference. The detailed participatory social mapping will be used to validate and update these existing spatial layers and to identify additional relevant features, including households, settlements, services, and environmental risks. GPS coordinates collected during the household census and health facility assessment will further support validation and spatial accuracy. We will geocode all mapped locations and standardize administrative codes across datasets. Each household will be assigned a unique household ID, and eligible household members will be assigned individual-level IDs nested within the household ID. Where consent has been obtained and individual-level identifiers are available, these IDs will facilitate linkage between individual household records and relevant health facility records. The household ID will support household-level and spatial analyses, while the individual-level ID will enable linkage of health service utilization and facility records to the appropriate household member. Where individual-level linkage is not feasible, household and facility data will be linked spatially using common geographic identifiers to assess health service availability and facility readiness in relation to household and population characteristics. This approach will allow cross-referencing of household health indicators with relevant health facility information and nearby facility readiness, while maintaining appropriate privacy and confidentiality safeguards. Data cleaning and standardization will harmonize variables and ensure data quality through checks for inconsistencies and duplicate records. Routine government data will be incorporated and aligned with ward boundaries using common identifiers, supported

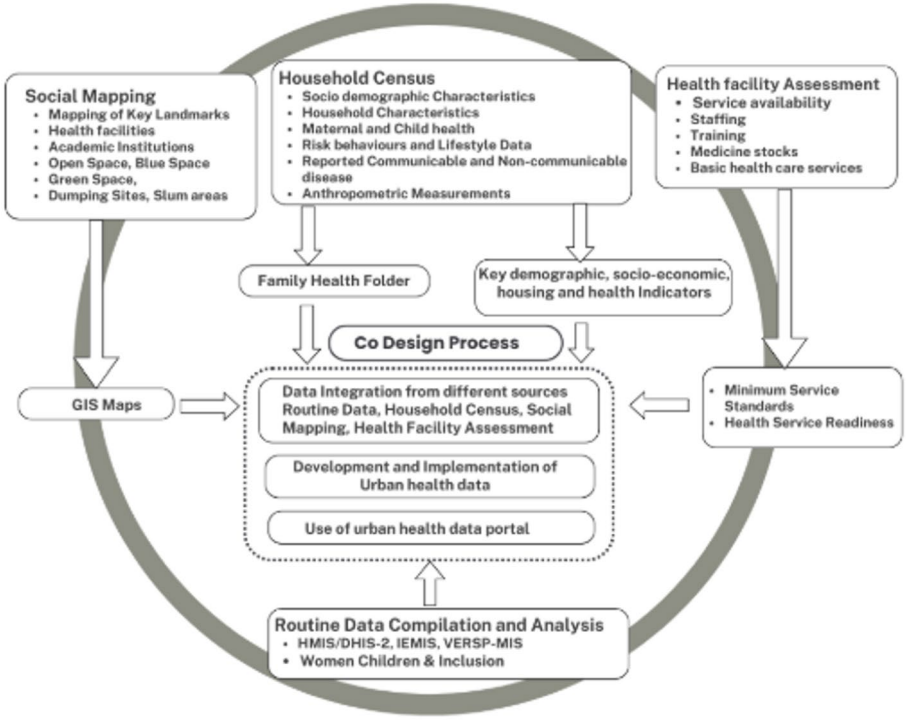


Fig. 1 Research approach for development of Urban health data Portal

by a comprehensive data dictionary. In collaboration with municipal stakeholders, we will co-create a user-friendly, web-based, multilingual portal accessible through computers and mobile devices (Fig. 1). We will adopt a user-centered design (UCD) approach, which emphasizes iterative engagement with end users throughout all stages of design, testing, and refinement. Municipal health officials and community representatives will be actively involved through participatory workshops, prototype testing sessions, and feedback loops to ensure that the portal's structure, visualizations, and functionalities align with their practical needs and digital capacities. This approach reflects established principles of user-centered design, which highlight the importance of engaging users to enhance system usability, acceptability, and long-term adoption [12, 13]. The integration of these primary datasets with routine municipal information within a unified urban health data portal is intended to provide immediate utility while strengthening the long-term sustainability of the data system.

Key features will include interactive dashboards displaying health indicators by ward, GIS mapping layers for household density, infrastructure, WASH coverage, and health outcomes, as well as basic analytics tools to identify hotspots and generate custom reports. Role-based access will ensure appropriate data security and privacy. To promote sustainability, the portal will be built on the open-source platforms DHIS2 enhanced with GIS modules, with thorough documentation and training provided to municipal IT staff. The Urban Health Data Portal will be routinely updated using relevant data collected and maintained by the municipality. Key household, environmental, and health service readiness indicators will be updated as new information becomes available through municipal records, routine monitoring, and periodic data collection. The designated municipal focal person will coordinate the provision and updating of relevant data, with support from concerned municipal departments and authorized data

providers. Newly available data will be reviewed, standardized, and incorporated into the portal using common indicator definitions, administrative codes, and reporting periods to maintain consistency and data quality.

The integrated and geo-referenced data system will support municipalities in identifying health inequities, prioritizing resources, and targeting interventions. By linking population characteristics, environmental risks, and health service coverage, the portal will provide a more comprehensive basis for evidence-informed urban health planning and decision-making.

2.11 Stakeholder engagement and cocreation

Throughout the project, we will maintain active stakeholder engagement, guided by principles of user-centered design to ensure that end users, including municipal officials and community representatives, are meaningfully involved in shaping the system's functionality, usability, and relevance. The primary users of the Urban Health Data Portal will be municipal health officials, municipal planners and decision-makers, ward officials, health facility managers, and relevant municipal departments involved in health planning, monitoring, and service delivery. Community representatives and other stakeholders will also be engaged as secondary users to access relevant, non-identifiable information on population characteristics, health services, environmental conditions, and community needs. This participatory approach will promote ownership, enhance user experience, and support the long-term sustainability of the portal. At key milestones including planning, social mapping, household census, and portal development we will hold co-creation workshops with municipal officials, the mayor, deputy mayor, department focal persons, and ward representatives, fostering collaborative decision-making and strong support for each activity. During the household census, we will discuss and identify innovative approaches tailored to the community's needs such as developing and distributing pamphlets to households and broadcasting jingles through local taxis to inform residents about the purpose and benefits of the census and to encourage active participation. These workshops will play a vital role in supporting the Urban Health Data Portal by bringing together diverse stakeholders to collaboratively shape its design, functionality, and implementation. Through open dialogue and shared decision-making, the portal will be tailored to local needs and priorities, fostering ownership among municipal officials, health workers, and community members. Co-creation will help identify relevant data sources, prioritize key health indicators, and develop user-friendly features suited to different users. Moreover, these workshops will be designed to facilitate capacity building by involving stakeholders directly in the process, increasing their ability to effectively use and maintain the portal. This collaborative approach aims to promote transparency, trust, and sustained engagement ultimately leading to a more responsive, inclusive, and impactful urban health data portal.

3 Discussion

Urbanization in low- and middle-income countries (LMICs) like Nepal presents complex health challenges characterized by rapid population growth, migration, and the expansion of informal settlements [2, 7, 14]. Addressing these challenges requires data systems that transcend traditional siloed approaches, integrating diverse data sources to capture the multifaceted determinants of urban health [11, 15]. This study describes an

ambitious effort to develop an integrated urban health data portal in a Nepalese municipality by combining routine administrative data with participatory mapping and household surveys. Our goal is to fill critical data gaps and facilitate equity-oriented urban health planning aligned with both local and global commitments such as the Sustainable Development Goals (SDGs), particularly SDG 11 on sustainable cities and communities [15, 16].

3.1 How integrated urban health data can help

An integrated urban health data portal – linking demographic, environmental, and service data at neighborhood scales can help municipalities tackle these challenges. Such systems combine maps of populations (even in slums) with layers on health facilities, water networks, and socioeconomic indicators. For instance, new geospatial methods (satellite imagery, mobile data, surveys) can now estimate key SDG indicators at high resolution. Recent projects have "modeled dozens of household survey indicators" (e.g. poverty, stunting, literacy) at 1 × 1 km or finer across entire countries [6, 17]. In practice, these data allow city planners to see precisely which informal neighborhoods lack clinics, sanitation or parks, and to monitor changes as slums expand. Area-level "health determinants" can include access to quality health facilities, traffic density, level of informality, pollution and social exclusion [12, 18] all measurable by integrating diverse datasets. Vital registration data such as records of births, deaths, marriages, and migration are examples of routine data collected continuously. Municipalities can utilize this routine data to strengthen their health information systems, improve population monitoring, and enhance planning and service delivery. Aggregating this information helps cities anticipate health service demand as people relocate. During outbreaks or seasonal epidemics, integrated urban data enable quicker, localized responses. For example, in western Kenya a digital HDSS used tablets and a central database (OpenHDS) to collect malaria data in real time [19]. This system ensured "quickly and effectively" gathered data with built-in quality checks, saving time and cost and demonstrating feasibility of electronic urban health surveillance [19]. Similarly, GIS-based dashboards (overlaying clinic cases, environmental risks and mobility patterns) have proven powerful in targeting vector control or immunization in Latin American slums and elsewhere. However, maintaining such a hub and keeping the data up to date presents significant challenges, including ensuring timely data collection, managing data quality, and integrating multiple data sources effectively.

3.2 The importance of integrated urban health data portal

Integrated data systems are increasingly recognized as foundational for "healthy cities" initiatives, enabling timely, evidence-informed decisions that improve health equity and service delivery [18, 20]. Unlike traditional top-down health surveillance systems, which often rely on aggregated or incomplete data, our approach adopts a bottom-up, cross-sectoral methodology. This reflects the complex social, environmental, and infrastructural determinants that shape urban health outcomes [17, 21]. An integrated health data portal enhances municipal capacity to identify underserved populations and allocate resources more fairly. For example, our preliminary data reveal that Ward 7 in Budhanilkantha municipality hosts a high density of informal settlers but is served by only one under-resourced clinic. Such insights prompt targeted investment and resource

mobilization, crucial for addressing inequities [12, 22]. Real-time dashboards enable continuous monitoring of health indicators, such as spikes in diarrheal disease following floods, facilitating rapid response and containment [13, 14, 23]. This "making visible" of the urban poor addresses equity concerns by ensuring that marginalized groups are not overlooked in data-driven planning.

3.3 Addressing equity and service gaps

Equity remains central to our project, as urban health disparities are often compounded by factors like migration status, informal settlement residence, and lack of insurance coverage [5, 24]. By capturing detailed data on these populations, we quantify service gaps, such as the proportion of children in Ward 4 who are not enrolled in school or remain unvaccinated. Furthermore, linking household-level data to health facility readiness exposes spatial mismatches areas with high need but inadequate services highlighting inefficiencies that would otherwise remain hidden [8, 18, 25]. Such granular, disaggregated data are indispensable for aligning local interventions with national and global policy goals. The project's focus on equity supports Nepal's commitment to universal health coverage and the SDGs, emphasizing inclusive urban growth and access to quality health services for all [18, 24, 26].

3.4 Policy and planning implications

The integrated data portal directly informs municipal decision-making processes. Ward officials can utilize it to draft health budgets, plan the location of new clinics, and monitor progress toward local health goals. Additionally, the portal provides robust evidence to support proposals to regional and national authorities, strengthening advocacy for equitable urban health investments [14, 27]. By demonstrating the feasibility and utility of such a system in a pilot municipality, this project lays the groundwork for scaling integrated health data systems nationally. Dissemination of policy briefs and targeted forums will engage policymakers, facilitating institutional adoption and alignment with broader urban development agendas [12, 28].

3.5 Scalability and adaptability

Although this study focuses on two wards within Budhanilkantha municipality, the data architecture built on common unique identifiers and GIS layers is designed to be scalable and adaptable. The framework can be extended to additional wards and municipalities, with flexible mapping indicators that other cities can tailor to their specific contexts, such as air quality sensors or traffic accident hotspots [23, 29]. Documenting implementation lessons around staffing, technology requirements, and costs will provide practical guidance for replication and scaling, addressing a common gap in urban health data initiatives [24, 30].

3.6 Future directions

Post-implementation, the portal aims to integrate additional data layers including environmental sensors monitoring air and water quality, as well as urban mobility data to capture broader determinants of health. Incorporation of advanced analytics, such as predictive modeling for forecasting disease outbreaks or service demand, could further enhance decision-making capabilities [8, 21, 31]. The portal also envisions evolving into

a community-facing platform enabling public health alerts and citizen reporting via mobile apps, fostering community engagement and real-time feedback [13, 32]. Long-term, integration with national health information systems will improve continuity of care for migrants and facilitate policy evaluation at granular administrative levels, critical for assessing program impact and refining health strategies [18, 33].

4 Conclusion

This study will produce a detailed protocol for developing equitable urban health data portal through an innovative mix of routine data integration and primary data collection. Key contributions include: (i) demonstrating the feasibility of combining participatory mapping, household census, and facility surveys with existing municipal data; (ii) outlining the technical framework for an integrated data portal (dashboards, GIS maps, analytics) to support ward-level planning; and (iii) providing evidence on urban health inequities to inform inclusive governance. We will offer the following recommendations: First, national and municipal governments should invest in local health data infrastructure, including GIS capacity and interoperable information systems. Second, multisectoral collaboration is essential; data from health, water, education, and other sectors must be pooled for a complete picture of urban well-being. Third, this model should be scaled up: pilot results will guide expansion to more wards and cities, with adaptations as needed. Fourth, community engagement throughout the process fosters data ownership and ensures that the system addresses real needs. Finally, we call on policymakers and development partners to support integrated, resilient urban health data portal as a priority in rapidly urbanizing LMICs. Effective implementation of such systems will help achieve equitable access to health services and improve outcomes for all city residents.

Author contributions

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Funding

This research has been funded by UK aid from the UK government; however, the views expressed do not necessarily reflect the UK government's official policies. This study was conducted as part of the Community-led Responsive and Effective Urban Health System (CHORUS) Research Program Consortium, funded by Foreign, Commonwealth and Development Office (FCDO) with Grant Number: 301132.

Data availability

The datasets generated during and/or analysed during the current study are not publicly available due to confidentiality and privacy concerns but are available from the corresponding author on reasonable request.

Declarations

Ethical approval and consent to participate

Ethical approval for this study was granted by the Nepal Health Research Council (NHRC) (Registration No. 531/2024) and the University of Leeds Research Ethics Committee (Reference No. 2144). The study was conducted in accordance with the National Ethical Guidelines for Health Research in Nepal (NHRC, 2022), the Declaration of Helsinki, and the requirements of both research ethics committees. Municipal approval was obtained from the Budhanilkantha Municipal Executive. Data privacy was protected through de-identification of individual records, password-protected access controls, secure server hosting of the municipal website, and restricted user permissions. Written informed consent was obtained from all respondents before data collection.

Consent for publication

Not applicable as no identifiable data or images are presented in this manuscript.

Competing interests
The authors declare no competing interests.

Received: 16 March 2026 / Accepted: 30 September 2026
Published online: 07 October 2026

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