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Spatial Accessibility of Community-Based Child-Rearing Health Consultation Services in a Mixed Urban-Rural Municipality in Japan: An Open-Data GIS Analysis

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ABSTRACT

Background: Community-based child-rearing support services are essential for promoting equitable access to maternal and childcare. However, spatial inequities in accessibility may persist in municipalities that encompass both urban and rural areas. The expansion of open government data enables transparent evaluation of spatial accessibility in local health planning. **Purpose:** This study aimed to evaluate the spatial accessibility of community-based child-rearing health consultation services in Kanazawa City and to demonstrate a reproducible open-data GIS framework applicable to municipal-level child health planning. **Methods:** A cross-sectional spatial analysis was conducted using consultation site locations and population data in 250-m grid-cells for children aged 0–2 years. Network-based service areas were generated using predefined walking (900 m and 1,800 m) and driving (7.5 km and 15 km) distances. Both area-based coverage and population-weighted coverage within these service areas were calculated. **Results:** Forty-nine consultation sites were identified. At the 1,800-m walking-distance threshold, service areas covered 76.1% of child-inhabited residential grid areas and 86.5% of the population aged 0–2 years, indicating higher population-weighted coverage than area-based coverage. In contrast, driving-distance service areas encompassed nearly all residential grid areas and virtually all children within the municipality. **Conclusions:** Pedestrian accessibility to child-rearing consultation services varies within this mixed urban–rural municipality, leaving geographically dispersed areas underserved despite relatively high population-weighted coverage in urban districts. Open-data-driven spatial analysis using both area-based and population-weighted indicators provides a scalable framework for identifying spatial inequities and supporting evidence-based municipal child health planning

KEYWORDS
Spatial accessibility, Geographic information system, Child health services, Open data, Urban-rural disparities

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1. BACKGROUND

Community-based health and child-rearing support services constitute fundamental components of equitable public health systems, particularly in promoting early childhood development

and reducing disparities in access to preventive care. Early childhood represents a critical developmental period during which timely intervention can influence long-term physical, cognitive, and psychosocial outcomes. In particular, the first two years of life constitute a critical developmental window characterized by rapid physical, cognitive, and psychosocial growth; therefore, this study focuses on children aged 0–2 years. Municipal consultation services particularly target caregivers of infants and toddlers during this period, when early support and parental guidance are most relevant. Ensuring access to consultation and support services for families with young children is therefore both a matter of service provision and health equity and social investment. When services are unevenly distributed or geographically inaccessible, existing socioeconomic and spatial disparities may be exacerbated.

At the same time, the expansion of open government data has facilitated the evaluation of service accessibility and population needs with enhanced transparency and reproducibility. Publicly available demographic and geographic datasets support evidence-based planning and strengthen accountability in local governance. International frameworks emphasize equity and data-informed planning in early childhood health systems (World Health Organization, 2018), while open-data initiatives underscore the role of accessible public datasets in governance and accountability (Janssen et al., 2012). Spatial accessibility theory further highlights the importance of integrating demographic and geographic data in local decision-making (Guagliardo, 2004). Because service allocation decisions are generally made within administrative jurisdictions, assessment at the municipal level is particularly relevant (Zhang et al., 2018).

Geographic Information Systems (GIS) have been extensively applied to evaluate spatial accessibility to health and social services, including maternal and child health and primary care. By integrating population distribution data, facility locations, and transportation networks, GIS-based analyses identify geographic discrepancies between service supply and potential demand. Empirical studies combining census data, facility location data, and network-based measures have demonstrated persistent spatial inequities, including in urban settings with relatively dense service provision (Luo & Qi, 2009). Subsequent methodological developments have refined measures of spatial accessibility and equity

in health service distribution (Wang, 2012), incorporating advanced techniques such as fuzzy inference systems to capture graded accessibility (Sabokbar et al., 2021). Network-based analyses and reproducible GIS workflows have increasingly been emphasized for policy-relevant evaluation and health planning (Vadrevu & Kanjilal, 2016). Nevertheless, implementation within local government contexts remains constrained by technical capacity, data integration challenges, and resource limitations.

In Japan, GIS has been employed to assess healthcare resource distribution and accessibility, including home visiting nursing services (Naruse et al., 2017), obstetric care concentration (Koike et al., 2010), public health nurse density (Mizutani et al., 2025), and disaster preparedness for medically vulnerable populations (Nakai et al., 2018). However, a recent national survey reported that only 28% of Japanese municipalities utilize GIS for community assessment (Akatsuka et al., 2025), indicating limited institutional integration in municipal health planning. This discrepancy between methodological potential and practical implementation underscores the need for applied case studies that translate technical approaches into operational workflows for municipal practitioners.

Many Japanese municipalities encompass both densely populated urban districts and peripheral or mountainous areas within a single administrative boundary. In such mixed urban–rural contexts, disparities in access may arise not only between municipalities but also within them. Geographic dispersion, transportation constraints, and uneven distribution of health personnel may result in localized reductions in accessibility, even where aggregate service coverage appears adequate. Rural and semi-rural areas are often characterized by transportation constraints, uneven distribution of health personnel, and geographic barriers that influence maternal and child health service accessibility (Naruse et al., 2017; Koike et al., 2010; Mizutani et al., 2025; Nakai et al., 2018). Fine-scale spatial evaluation is therefore relevant for municipal planning and public health nursing practice across urban–rural continua.

The present study demonstrates a practical application of GIS-based spatial analysis for municipal child health service planning. In Japan, municipalities play a central role in delivering maternal and child health services, frequently through

community-based programs administered by public health nurses. Machino Kosodate Hokenshitsu is a municipal initiative implemented by Kanazawa City that provides regular child-rearing and health consultation opportunities in familiar community settings, such as community centers and public facilities. The program targets pregnant women and caregivers of young children and aims to reduce psychological burden, facilitate early support, and strengthen connections between families and local health professionals. It is positioned within Kanazawa City's broader child-centered policy framework, which emphasizes accessibility within daily living environments.

Despite growing recognition of the importance of spatial equity in health service delivery, empirical evidence at the municipal level remains limited, particularly regarding community-based child-rearing consultation services. Most prior research has focused on large-scale regional analyses or specialized healthcare systems, leaving intra-municipal disparities insufficiently examined. Given that maternal and child health programs in Japan are planned and implemented within municipal administrative boundaries, accessibility assessment at this scale is directly relevant for policy and practice. A transparent and reproducible analytic framework is therefore needed to support routine municipal health planning and to identify localized gaps in service coverage within mixed urban–rural settings.

Therefore, the objectives of this study were twofold: (1) to evaluate the spatial accessibility of Machino Kosodate Hokenshitsu consultation sites relative to the residential distribution of children aged 0–2 years in Kanazawa City, and (2) to demonstrate a reproducible, open-data GIS workflow that can be implemented for routine municipal child health planning in mixed urban–rural contexts.

2. METHODS

Design

This study employed a cross-sectional descriptive spatial analysis using publicly available open data to assess municipal-level spatial accessibility to community-based child-rearing health consultation services. Using open-source GIS tools, we evaluated the spatial alignment between consultation site locations and the residential distribution of children aged 0–2 years within Kanazawa City at a single time point, and present the workflow as a reproducible framework for routine municipal child health planning.

Sample and Setting

This study was conducted in Kanazawa City, Ishikawa Prefecture, Japan (Figure 1). Situated in western Japan, Kanazawa City includes densely populated urban districts and peripheral mountainous areas within a single administrative boundary. Compact residential neighborhoods are concentrated in the western and central districts, whereas the eastern and southeastern regions are characterized by lower population density and more complex terrain. This mixed urban–rural structure provides an appropriate context for examining intra-municipal disparities in spatial accessibility.

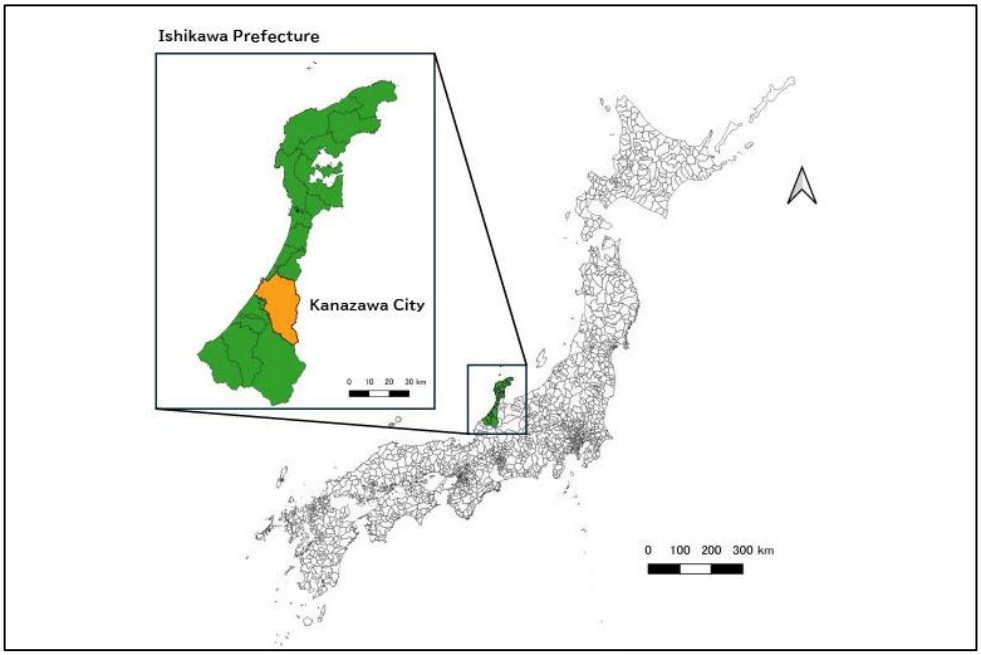

Figure 1. Geographic location of Kanazawa City within Ishikawa Prefecture, Japan
Administrative boundary data were obtained from the National Land Numerical Information, Ministry of Land, Transport and Tourism of Japan

Kanazawa City operates community-based child-rearing health consultation services (Machino Kosodate Hokenshitsu) as part of its maternal and child health programs. The program is generally organized at approximately the elementary school district level. While the city has 54 elementary school districts, 49 consultation sites are currently in operation. These consultation sessions are held periodically at community centers and public facilities to facilitate local access. The analytical sample included all officially listed consultation sites within the city (N = 49) and all residential geographic units with available demographic data. All spatial units within the municipal boundary were included to

ensure comprehensive geographic coverage.

Variables

Potential demand for child-rearing support services was represented by the population of children aged 0–2 years aggregated at the 250-m grid-cells level. This resolution was selected to capture fine-scale residential variation while maintaining compatibility with nationally standardized demographic datasets. Use of small-area grid data enabled identification of localized clusters that may not be apparent at larger administrative scales.

Service provision was represented by the geographic point locations of consultation sites. Accessibility was evaluated using predefined walking and driving-distance thresholds derived from estimated travel speeds. Although initially derived from time-based assumptions, accessibility was operationalized as fixed network distances. The primary outcome was the coverage rate of child-inhabited residential grid areas within predefined service areas.

Data Collection

Location data for consultation sites were obtained from publicly available municipal documents released by Kanazawa City (Kanazawa City, n.d.). Site addresses were verified and geocoded to generate spatial point data. Population data were derived from the 2020 Population Census small-area statistics (250-meter grid data) published by the Statistics Bureau of Japan (Statistics Bureau of Japan, 2022). These datasets contain aggregated counts without personal identifiers.

Administrative boundary data were obtained from the National Land Numerical Information provided by the Ministry of Land, Infrastructure, Transport and Tourism of Japan (Ministry of Land, Infrastructure, Transport and Tourism, n.d.). These data were used to define the municipal study boundary and to ensure consistent spatial referencing across all datasets.

Road network data were obtained from OpenStreetMap (OpenStreetMap contributors, 2026). The dataset was downloaded in January 2026 and processed to construct a routable street network. Prior to analysis, the dataset was examined for disconnected segments and geometric inconsistencies to ensure topological connectivity. All road segments accessible for general travel were retained, and no differentiation by road class was applied, as the objective was to estimate geographic reach rather than traffic flow dynamics. All

spatial datasets were transformed into a unified projected coordinate reference system to ensure accurate distance calculations and minimize spatial distortion during overlay procedures.

Data Analysis

All spatial analyses were conducted using GIS software QGIS (version 3.44.7; QGIS Development Team). Network-based accessibility analysis was performed using QNEAT3, a network analysis toolbox integrated within QGIS. Prior to analysis, all spatial layers were projected onto a consistent coordinate reference system to ensure accurate distance calculations.

The walking-distance thresholds were calculated based on an assumed walking speed of 1.0 m/s, representing a conservative estimate relative to typical comfortable adult walking speeds reported in biomechanical studies (Fukuchi et al., 2019). Previous systematic reviews have demonstrated that gait parameters systematically decrease at slower walking speeds, supporting the use of a reduced-speed assumption to approximate mobility conditions, such as caregivers accompanying young children (Forde & Daniel, 2021). Based on this speed, the travel distances corresponding to 15 and 30 min were calculated to be approximately 900 and 1,800 m, respectively. For driving accessibility, an average speed of 30 km/h was assumed to reflect the typical urban driving conditions within the municipality. These assumptions yielded network distances of 7.5 and 15 km corresponding to 15- and 30-min travel times, respectively. These predefined distances were used as fixed network distances for the analysis. Although derived from time-based assumptions, the use of distance thresholds allowed for clearer spatial comparisons across walking and driving conditions. Network-based service areas were calculated independently from each consultation site and subsequently merged to generate composite service areas for each threshold. This procedure enabled the identification of overlapping service zones in densely populated districts and isolated service catchments in peripheral regions. Coverage was evaluated separately for each distance threshold and travel mode.

To generate the service areas, network-distance calculations were used instead of straight-line (Euclidean) buffers to better approximate the actual travel routes constrained by road connectivity. This approach reduces the overestimation of accessibility, which may occur when

geographic barriers or indirect routes are present. The analysis prioritized transparency and reproducibility by employing standardized procedures available within widely used open-source software.

A spatial overlay analysis was conducted to identify child-inhabited residential grid cells intersecting each service area. Child-inhabited residential grids were defined as 250-m grid cells with non-zero populations of children aged 0–2 years. Coverage was evaluated using both area-based coverage and population-weighted coverage in order to capture complementary aspects of spatial accessibility. Area-based coverage represents the proportion of child-inhabited residential grid areas located within each service area, whereas population-weighted coverage represents the proportion of children aged 0–2 years residing within those service areas.

The coverage rates were calculated using the following formulas:

Area-based Coverage (%) = (Area of child-inhabited residential grids intersecting with service areas ÷ Total area of child-inhabited residential grids) × 100

Population-weighted Coverage (%) = (Population of children aged 0–2 years residing within service areas ÷ Total population of children aged 0–2 years) × 100

To calculate population-weighted coverage, the 250-m population grid for children aged 0–2 years was spatially overlaid with each service area. For grid cells partially intersecting a service area, the covered population was proportionally allocated based on the intersected area.

The area-based coverage measure emphasizes the geographic extent of service accessibility, whereas the population-weighted coverage reflects the proportion of children potentially served. Reporting both indicators allows complementary interpretation of spatial accessibility, particularly in municipalities where population distribution is uneven across urban and peripheral areas. By focusing on the proportion of geographically inhabited grid areas within the service reach, the analysis highlighted the presence of uncovered residential zones regardless of their population size. This perspective aligns with municipal planning considerations, in which geographic equity and territorial coverage are often evaluated alongside demographic indicators. Although population-weighted measures may provide additional precision, the area-based measure offers a clear baseline assessment

of spatial accessibility patterns within municipalities. As the analysis relied exclusively on aggregated spatial units and publicly available datasets, no linkage of individual-level information was performed at any stage of data processing. All analytical procedures were conducted within a secure local computing environment, and no personal identifiers were accessed or stored.

Ethical Consideration

This study used publicly available aggregated data and excluded identifiable personal information. No individual-level data were available for this study.

3. Results

A total of 49 community-based child-rearing health consultation sites were identified within Kanazawa City. As illustrated in Figure 2, the sites were distributed across the municipality, with a higher concentration in the western and central urban districts. In these areas, several sites were located in relatively close proximity, forming clusters of service availability. In contrast, the eastern and southeastern regions, characterized by mountainous terrain and more dispersed residential patterns, contained fewer consultation sites.

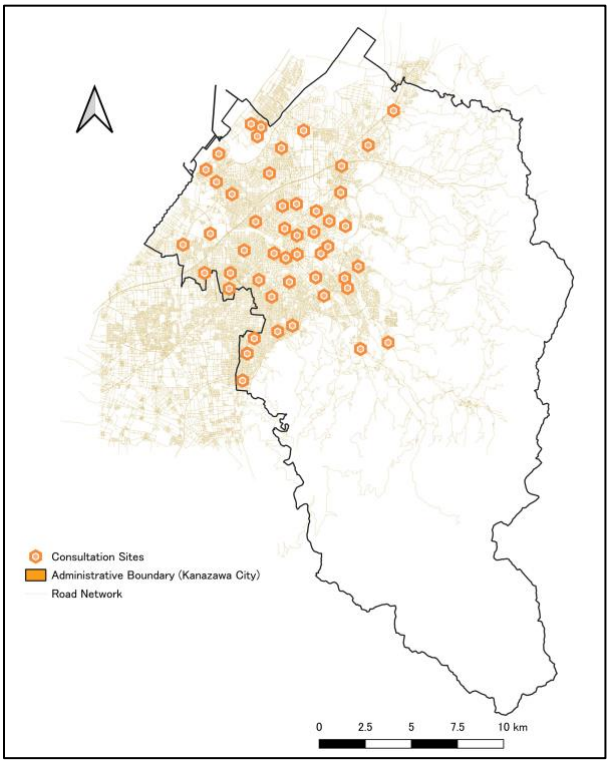

Figure 2. Spatial distribution of community-based health consultation sites
Administrative boundary data were obtained from the National Land Numerical Information. Consultation site data were obtain from publicly available documents released by Kanazawa City. Road network data were obtained from OpenStreetMap. © OpenStreetMap contributors.

Overall, the spatial distribution of sites varied across the city in accordance with settlement density. The distribution of children aged 0–2 years also showed substantial geographic variation across Kanazawa City (Figure 3). Higher concentrations were observed in the western and central residential districts, where contiguous 250-m grid cells displayed moderate to high population counts. These areas largely corresponded to established residential neighborhoods and mixed-use urban zones. In contrast, many grid cells in the peripheral and mountainous eastern and southeastern regions had sparse or zero child populations, reflecting lower residential density. Nevertheless, several isolated grid cells with non-zero child populations were identified in these peripheral areas, indicating the presence of dispersed households with young children outside the urban core.

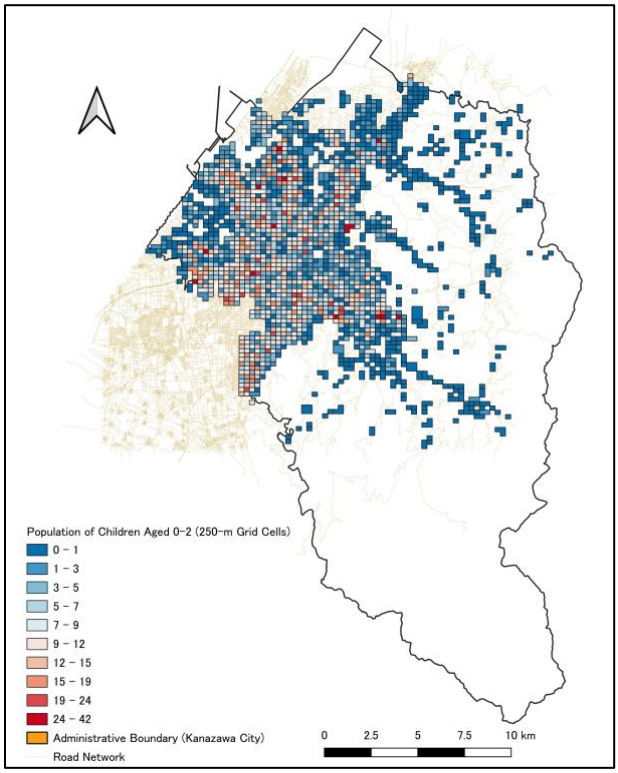

Figure 3. Distribution of children aged 0-2 years by 250-m grid cells
Administrative boundary data were obtained from the National Land Numerical Information. Population data (250-meter grid statistics) were obtain from the Statistics Bureau of Japan. Road network data were obtained from OpenStreetMap. ©OpenStreetMap contributors.

Network-based service areas generated using QNEAT3 revealed variation in accessibility to consultation sites. As shown in Figure 4, walking-distance service areas of 900 m and 1,800 m were concentrated primarily in the western and central urban districts, where overlapping

catchments created relatively continuous zones of pedestrian accessibility. In these districts, a large proportion of child-inhabited grid cells fell within at least one walking-distance service area. However, several 250-m grid cells with non-zero child populations were located beyond these walking thresholds, particularly in peripheral and mountainous areas. These uncovered grid cells were generally situated at greater network distances from the nearest consultation site and were more spatially dispersed.

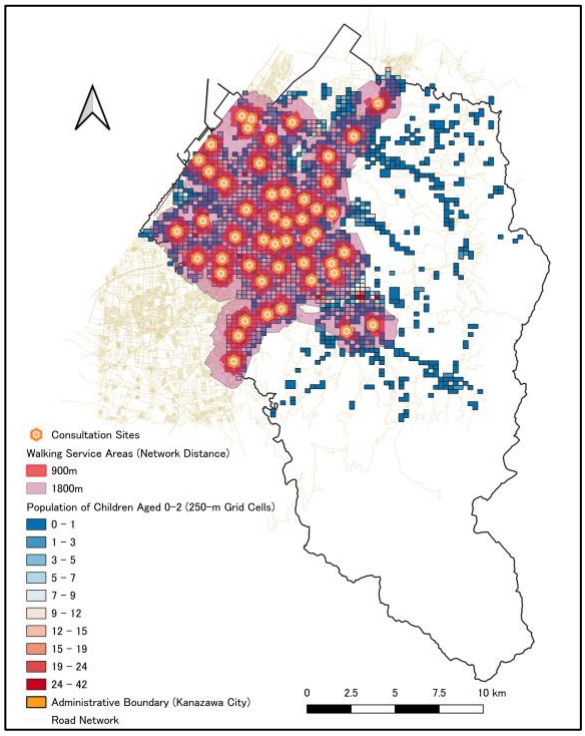

Figure 4. Distribution of children aged 0-2 years by 250-m grid cells and walking service area from consultation sites

Administrative boundary data were obtained from the National Land Numerical Information. Population data (250-meter grid statistics) were obtain from the Statistics Bureau of Japan. Consultation site data were obtained from publicly available documents released by Kanazawa City. Road network data were obtained from OpenStreetMap. © OpenStreetMap contributors.

Table 1. Area-based and population-weihgted coverage of consultation services areas

Distance threshold	Area-based coverage (%)	Population-weighted coverage (%)
Walking Service Areas 900m	37.5	58.9
Walking Service Areas 1800m	76.1	86.5
Driving Service Areas 7.5km	96.1	98.1
Driving Service Areas 15km	99.9	100.0

Area coverage represents the proportion of child-inhabited residential grid areas located within each service area. Population coverage represents the proportion of child aged 0-2 years residing within these service areas based on the 250-m population grid.

As shown in Table 1, the 900-m walking service areas covered 37.5% of the total area of child-inhabited residential grids, while 58.9% of children aged 0–2 years resided

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within these areas. When the walking threshold was extended to 1,800 m, 76.1% of residential grid areas and 86.5% of the child population were included within the service areas. Although most residential areas where children aged 0–2 years reside were covered under the 1,800-m walking threshold, a substantial proportion of geographically dispersed residential grids remained beyond the walking-distance service areas. Notably, population-weighted coverage was consistently higher than area-based coverage at both walking thresholds, indicating that young children were relatively concentrated in densely populated residential districts.

In contrast, driving-distance service areas showed substantially higher accessibility (Table 1; Figure 5). The 7.5-km driving threshold covered 96.1% of residential grid areas and 98.1% of the child population, while the 15-km threshold covered 99.9% of residential grid areas and virtually all children (100.0%) within the municipality. These network-based driving service areas formed extensive coverage zones spanning both urban and peripheral regions, resulting in near-complete accessibility at the municipal scale.

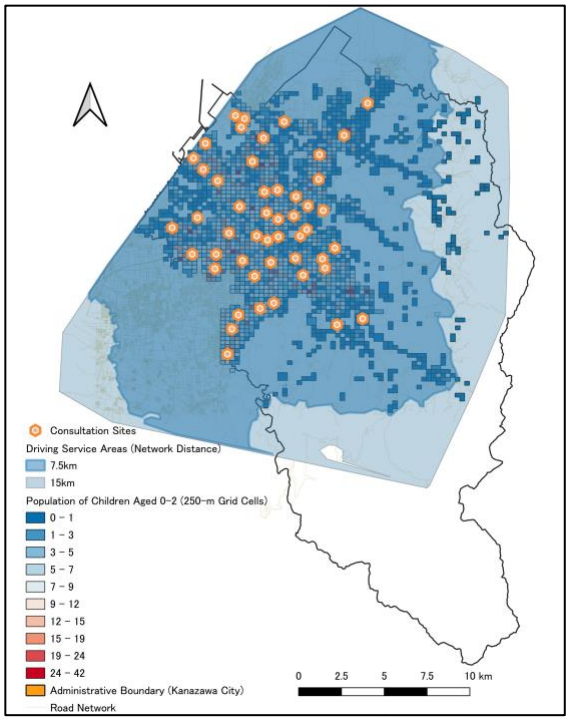

Figure 5. Distribution of children aged 0-2 years by 250-m grid cells and driving service area from consultation sites

Administrative boundary data were obtained from the National Land Numerical Information. Population data (250-meter grid statistics) were obtain from the Statistics Bureau of Japan. Consultation site data were obtained from publicly available documents released by Kanazawa City. Road network data were obtained from OpenStreetMap. © OpenStreetMap contributors.

4. DISCUSSION

This study makes two principal contributions. First, it provides a fine-scale assessment of intra-municipal variation in pedestrian and driving accessibility within a mixed urban–rural municipality. Second, it demonstrates a reproducible open-data and open-source GIS workflow that can be implemented in routine municipal child health planning. By integrating population data in 250-m grid-cells for children aged 0–2 years with network-based service areas, the analysis identified measurable disparities in pedestrian accessibility despite the geographic distribution of multiple consultation sites.

Although consultation sites are distributed across the city, walking-distance accessibility does not uniformly cover all residential areas inhabited by children aged 0–2 years. The area-based coverage rate of 76.1% indicates that approximately one-quarter of child-inhabited residential grid areas fall outside the predefined 1,800-m walking-distance service areas. When population distribution is considered, however, a larger proportion of children (86.5%) reside within these service areas, reflecting the concentration of young children in relatively dense residential districts. These uncovered areas were concentrated in peripheral and geographically dispersed districts rather than randomly distributed, suggesting localized clustering of spatial disadvantage. This mismatch between potential demand and pedestrian accessibility indicates that inequities may persist even when multiple service sites exist within a municipality. These findings align with prior research demonstrating that geographic disparities can remain despite apparently adequate service density at the municipal level (Guagliardo, 2004; Luo & Qi, 2009).

A notable difference was observed between the 900-m and 1,800-m walking-distance thresholds. While the 900-m walking service areas covered only 37.5% of child-inhabited residential grid areas, they encompassed 58.9% of the child population. This discrepancy suggests that many children reside in relatively compact urban neighborhoods where consultation services are located within a short walking distance. At the same time, it indicates that households living in more dispersed peripheral districts may face greater barriers to accessing consultation services on foot. From a municipal child health planning perspective, these findings highlight the importance of considering short-distance pedestrian accessibility when designing

community-based consultation programs intended to support caregivers with infants and toddlers.

Methodologically, the study demonstrates the feasibility of integrating publicly available demographic data with open-source GIS tools for municipal health planning. While advanced models, such as enhanced floating catchment area methods offer refined service-to-population estimates, they often require detailed supply-side data and technical expertise not consistently available at the municipal level. In contrast, the network-distance approach applied here relies on accessible datasets and widely available software, reducing technical barriers to implementation. The reproducible workflow presented provides a scalable framework for municipalities with limited analytical resources.

Kanazawa City encompasses densely populated urban districts as well as peripheral and mountainous areas within a single administrative boundary. In such mixed urban–rural settings, disparities may arise within municipalities rather than solely between them. The findings illustrate how municipal-level averages can obscure localized accessibility gaps. Place-based health disadvantages have been documented across diverse settings, emphasizing the influence of geographic location on service accessibility and health outcomes (Cosby et al., 2019). Rural health research further identifies geographic isolation, transportation barriers, and uneven service distribution as structural contributors to health inequities (Smith et al., 2008; Probst et al., 2023). In addition, differences in help-seeking behavior and perceived accessibility between rural and urban populations may influence service utilization beyond geographic proximity (Farmer et al., 2006). Fine-scale spatial analysis therefore offers practical value for identifying intra-municipal disparities relevant to public health nursing practice.

The identification of residential clusters with relatively high concentrations of children aged 0–2 years located outside walking-distance service areas has practical implications for public health nursing. Spatial information on underserved neighborhoods may inform targeted outreach scheduling, temporary consultation sessions, or collaboration with community organizations in peripheral districts. Visual representation of accessibility gaps may also support dialogue between municipal planners and frontline nursing staff, facilitating strategic allocation of limited human resources in contexts of

workforce constraints and demographic change.

Although driving-distance service areas encompassed nearly all child-inhabited residential grids, automobile-based coverage does not ensure equitable access. Dependence on private vehicles may disadvantage households without reliable transportation, and access to automobiles may vary by socioeconomic status, family structure, and geographic location. Transportation barriers are recognized determinants of healthcare access (Syed et al., 2013), and travel distance and time remain important predictors of healthcare utilization, particularly in rural and remote areas (Mao et al., 2024). Caregivers without consistent vehicle access, those with multiple young children, or those residing in peripheral districts may face barriers to services beyond walking distance. Evaluating pedestrian accessibility therefore provides an equity-oriented perspective even when motorized coverage appears comprehensive. The findings also highlight the importance of considering service capacity. Spatial proximity does not guarantee adequate availability. Variations in session frequency, staffing levels, and appointment capacity may produce differences in service intensity across sites. Future research should incorporate capacity-based measures, including population-to-site ratios and public health nurse staffing data, to assess proportionality between service distribution and local demand. Longitudinal analyses examining changes in population distribution and service locations would further clarify evolving accessibility patterns.

Several limitations warrant consideration. First, accessibility was defined using fixed travel speeds and distance thresholds, which may not fully capture variations in terrain, traffic conditions, or caregiver mobility constraints. Second, although both area-based and population-weighted coverage measures were calculated, the analysis relied on aggregated grid-level population data and therefore may not fully capture micro-scale residential variation within each grid cell. Third, the study relied exclusively on demand-side population data and did not incorporate supply-side variables, such as staffing or service frequency. Finally, actual service utilization was not evaluated and may be influenced by sociocultural, informational, and behavioral factors beyond geographic proximity (Levesque et al., 2013; Farmer et al., 2006). In the present analysis, population-weighted coverage was

consistently higher than area-based coverage, reflecting the concentration of young children in urban residential districts. Reporting both indicators helps distinguish between geographic reach and the proportion of the population effectively served, which is particularly important in municipalities that include both densely populated urban areas and sparsely populated peripheral regions. Future studies should integrate mixed-method approaches to provide a more comprehensive assessment. Despite these limitations, the study demonstrates that open-data–based GIS analysis can generate policy-relevant evidence for municipal maternal and child health planning. In mixed urban–rural municipalities, geographic dispersion and transportation constraints shape accessibility patterns. Translating publicly available demographic data into policy-relevant spatial evidence supports equitable service allocation and strengthens evidence-informed municipal decision-making.

Beyond its conceptual contribution, the present workflow offers a concrete operational tool for routine municipal assessment. The use of nationally standardized grid statistics and openly available road-network data allows periodic re-analysis as population distribution and service locations change. In practice, municipalities could apply the same procedure to compare alternative site configurations (e.g., adding temporary sessions, rotating outreach locations, or relocating services) and to visually communicate trade-offs between pedestrian and vehicle-based access. Such outputs may be particularly useful for interdisciplinary discussion among public health nurses, planning officers, and community stakeholders, because the maps provide an intuitive representation of where families may face geographic barriers. In addition, the approach can support monitoring of equity-oriented policy targets by establishing a baseline and enabling consistent comparisons over time. Because both area-based and population-weighted indicators were calculated in the present analysis, the framework can flexibly accommodate different evaluation perspectives depending on planning objectives. Collectively, these features strengthen the practical relevance of open-data GIS for evidence-informed decision-making in mixed urban–rural municipalities. Furthermore, the approach demonstrated in this study may facilitate inter-municipal comparison when standardized grid-based demographic data are available across

regions. By applying consistent distance thresholds and transparent analytical procedures, municipalities can benchmark accessibility patterns and identify relative strengths and gaps in service distribution. Such comparative perspectives may support regional collaboration, shared learning, and the development of coordinated strategies to reduce geographic inequities in maternal and child health services.

5. CONCLUSION

This study demonstrated the utility of an open-data-driven GIS framework for evaluating the spatial accessibility to community-based child-rearing health consultation services within a mixed urban–rural municipality. By integrating population data in 250-m grid-cells for children aged 0–2 years with network-based walking and driving service areas, the analysis identified measurable intra-municipal disparities in pedestrian accessibility.

Although the consultation sites were geographically distributed across Kanazawa City, walking-distance accessibility did not uniformly cover all child-inhabited residential areas, and a non-negligible proportion of children also resided outside pedestrian-accessible service zones. Approximately one-quarter of these residential areas remained outside the predefined walking-distance service areas, indicating potential inequities in practical access despite the presence of multiple service locations. In contrast, driving-distance service areas encompassed virtually all residential grids, underscoring the importance of considering transportation modes when evaluating accessibility.

These findings highlight the relevance of fine-scale spatial analysis for municipal maternal and child health planning, particularly in municipalities that encompass both densely populated urban districts and peripheral or mountainous areas. In public health nursing practice, integrating open demographic data with network-based GIS analysis offers a transparent and reproducible approach for identifying underserved areas and informing equitable resource allocation.

By demonstrating a scalable and open-source workflow, this study contributes to the growing international literature on spatial equity in health services and provides a practical model for municipalities seeking to strengthen evidence-based, equity-oriented child health policy planning.

By identifying areas with limited pedestrian accessibility, local governments

can prioritize equity-oriented outreach and resource allocation. The use of publicly available data and open-source tools further supports the feasibility of this approach across municipalities with varying technical capacities.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest regarding the publication of this article.

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DATA AVAILABILITY

All data used in this study were obtained from publicly available open government datasets. Consultation site location data were derived from official documents published by Kanazawa City, and demographic data were obtained from publicly accessible 250-m grid statistics provided by the Statistics Bureau of Japan. Processed datasets and GIS workflows are available from the corresponding author upon reasonable request.

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