



Reducing the number of zero-dose children by 25 percent in Cameroon by 2025

Using geospatial-based composite score to identify and map missed communities.

Abstract

Vaccines have reduced disease burden and death in children; still, inequality in coverage continues to persist globally. Although Cameroon has made significant progress in vaccination since the start of the millennium, it remains one of the countries with the largest zero-dose population in Africa due to missed pockets of communities living in hard-to-reach areas. Zero-dose children are those that have not received diphtheria, pertussis, and tetanus vaccine (DPT 1). They are also likely to miss out on other healthcare services, further widening the health inequality gaps for under-five health services.

The traditional head counting approach typically employed in identifying unvaccinated children is expensive and unsustainable - especially on a national scale. Cameroon's Expanded Program for Immunization (EPI), supported by Clinton Health Access Initiative (CHAI), implemented a project to identify and characterize missed communities by triangulating data from different sources, including —Geographic Information System (GIS), District Health Information Software 2 (DHIS2), Demographic and Health Survey (DHS), Geo-Referenced Infrastructure and Demographic Data for Development (GRID3) and World Health Organization (WHO) data on health facility location. These communities were then ranked based on the probability of finding zero-dose children. This intervention will provide the platform for the EPI to prioritize communities for action based on available limited health resources.

Keywords: Zero-dose Identification, children, missed communities, vaccination, geospatial, data triangulation

Introduction

Vaccines are one of the world's safest methods for preventing infection from life-threatening diseases in children.¹ The introduction of vaccines over the last decade has led to significant reductions in vaccine-preventable diseases (VPD), childhood disability and death, and health inequalities in several parts of the world.² Cameroon has made remarkable progress in increasing vaccination coverage of DPT 1 from 54 percent in 2000 to 95.1 percent in 2013 and DPT 3 from 53 percent to 88.6 percent in the same period.³ Despite this progress, significant challenges exist with sustaining coverage and equity. Coverage for DPT1 declined from 95.1 percent in 2013 to 85.1 percent in 2019,³ resulting in an estimated 108,371 zero-dose children in 2019.⁴ Socio-political crisis in the northwest and southwest regions and the Boko Haram insurgency in the northern region hampered service delivery in these regions contributing to this decline.⁵ By 2021, the number of zero-dose children had increased to an estimated 112,118.⁴ While systemic challenges such as weak program, vaccine, and financial management, insufficient cold chain capacity, and insufficient human resources are underlying causes of declining coverages and increased number of zero dose children across all districts,⁶ there are some persistently poorly performing districts whose performances are affected by other factors and are often masked by national coverages.⁷ Among these factors, are enclaved and poorly accessible communities in arid, archipelago, nomadic, conflict, and fragile settings. Not only do they miss out on routine immunization, but also other primary healthcare (PHC) services.⁷

COVID-19 related disruptions worsened the situation for these communities as efforts and resources were vertically redirected to fight and respond to the pandemic in more accessible settings, resulting in an increased number of zero-dose children in these areas. The COVID-19 hotspot regions, Centre and Littoral recorded up to 34.7 percent and 29 percent rise in the number of zero-dose children respectively based on an immunization variation tracker (IVAT) analysis.⁸

In an effort to determine the true number of under-immunized and zero-dose children, CHAI with the EPI in 2019, surveyed six urban districts —Biyem-Assi, Efoulan, Cite Verte, Djoungolo, Nkoldongo and Nkolbisson and one rural health district Manoka —in Cameroon to identify under-immunized⁹ and zero-dose children.¹⁰ In total, 3,767 households in 91 of the 358 existing slums in the six urban districts were surveyed and 2,753 children aged between zero to 24 months were enumerated. Of the 2,753 children, 378 (13.7 percent) were zero-dose children, while 903 (32.8 percent) children above nine months were under-immunized.¹⁰ Similarly, 854 zero-dose children were identified in Manoka— a rural district. This survey suggested that there may be many more under-immunized and zero-dose children in other unidentified missed communities within the country such as densely packed, high-poverty urban communities or rural and hard to reach settings. The picture may be far worse in fragile and conflict areas.

Investments in identifying underserved communities and reaching zero-dose children with vaccination and other primary

¹ UNICEF 2021. <https://www.unicef.org/immunization>

² Andre F, et al. Vaccination greatly reduces disease, disability, death and inequity worldwide. *Bull World Health Organ.* 2008;86:140-6.

³ Official values from the WHO Immunisation dashboard. <https://immunizationdata.who.int/>

⁴ Estimated using data from DHIS2 (DPT 1 coverage used as an indicator)

⁵ Saïdu et al. *Conflict and Health* (2021) 15:8

<https://doi.org/10.1186/s13031-021-00341-0>

⁶ Children who have never received any vaccine antigen on the routine immunization calendar of the country. In this article, children who missed DPT 1 vaccine were considered zero-dose children.

⁷ Gavi (2021). The Zero-Dose Child: Explained <https://www.gavi.org/vaccineswork/zero-dose-child-explained>

⁸ IVAT is a tool developed by CHAI and EPI to analyze the impact of COVID-19 on RI by comparing routine immunization indicators between 2019 (pre-COVID-19 period) and 2020.

⁹ Children who have not taken all recommended vaccines for their age based on the EPI calendar for routine immunization.

¹⁰ CHAI et PEV (2020). Rapport sur le dénombrement des enfants de 0 - 24 mois et des femmes enceintes dans les zones précaires de 16 aires de santé cibles dans les 6 districts de santé de Yaoundé

healthcare services have been limited. CHAI led a collaborative multi-partner effort with EPI to develop a robust mechanism to facilitate the rapid identification, mapping, and prioritization of missed communities and zero-dose children. CHAI is collaborating with other partners to design context-specific interventions to reach these population groups. This paper aims to describe the methodology and results of the identification and characterization process for zero-dose children and missed communities. The impact of the strategies to reach zero-dose children will be documented in subsequent publications.

Methodology

- i. The approach aimed to identify, and map missed communities and rank them based on the probability of finding zero-dose children. A two-step process was used to achieve this: Generating a composite score that quantifies the likelihood of finding zero-dose children within health areas¹¹ in Cameroon.
- ii. Ranking and characterizing priority health areas that are most likely to have communities with zero-dose children.

First, characteristics at health area levels that are indicative of low access or use of vaccination and other health services were selected. Then facilities were assigned a composite score based on a weighted average of the characteristics, ranked in relative importance in preventing accessibility or use of vaccination and other PHC services.¹² The composite score was a proxy for the likelihood of finding zero-dose children in that health area.¹³ The following health area characteristics were used:

- i. **The number of hard-to-reach settlements in a health catchment area:** In rural areas, hard-to-reach (HTR) settlements were defined as an area beyond a 15 km radius of health facilities providing vaccination services - this is well

beyond the five-km radius required for outreach vaccination activities. For urban areas, HTR settlements were defined as those beyond a one km radius to the closest health facility providing vaccination services. Health areas with a higher number of settlements beyond the defined boundaries were more likely to contain zero-dose children.

- ii. **The number of slums and new settlements in a health catchment area:** We used the proportion of a health area covered by slums or new settlements as a proxy for the likelihood of containing zero-dose children. Health areas with a higher number of slums and new settlements indicated a higher likelihood of finding zero-dose children.
- iii. **Health catchment area non-vaccination rate (DPT 1 used as an indicator for vaccination access):** This refers to the percentage of children not vaccinated for DPT 1 in the health area in 2020. The DPT coverage rate for each health area in the year 2020 was obtained from DHIS-2 and used to calculate the percentage of unvaccinated children for each health area. A higher percentage of unvaccinated children for DPT-1 for a given health area indicated a higher likelihood to contain zero-dose children.

Data sources

We obtained the geographical location of the different health facilities in Cameroon offering vaccination services from DHIS2 and WHO office in Cameroon. Health facilities providing vaccination services were operationally defined as those declared by the WHO to be providing these services or had reported (in DHIS2) the number of children vaccinated with DPT1 between January 1 and December 31, 2020. We obtained data on all settlements in Cameroon from GRID3 data) which reports the location for three types of settlements: built-up areas (BUA), small settlement areas (SSA), and hamlets. BUA are urban areas with

¹¹A health area is a group of communities demarcated based on cultural characteristics, population size amongst others; that serves as the basic territorial framework for the Primary Health Care (PHC) delivery system.

¹²The weights were iteratively determined by researchers, EPI and Vaccine experts at CHAI

¹³ Field validation of the accuracy of these proxies is planned.

moderately-to-severely-spaced buildings with visible street and block grids. BUA usually contain about 400,000m² with a building density ≥ 30 across the entire area. SSA are permanently inhabited structures and compounds of a few hundred to a few thousand inhabitants. SSA are non-built-up areas characterized by ≥ 50 buildings. Finally, hamlets consist of several compounds or sleeping houses in isolation from small settlements or urban areas. They are characterized by low-density settlements between one and 50 buildings that fall within 65 meters of one another. Data on slums and new settlements were obtained from Clinton Health Access Initiative (CHAI), Cameroon.

Calculating the composite score

After calculating the value of each indicator: the number of HTR built-up areas, small settlement areas and hamlets, amount of area covered by slums and new area settlements and percentage of children unvaccinated for DTP-1 per health area, the values were ranked into percentile groups to ensure that the indicators used to generate the score are on a standardized unit scale before combining them into a single summary score. Each indicator was then assigned a weight based on the relative importance of the indicator in capturing accessibility or use of vaccination and other related primary healthcare services.

The relative importance of these indicators was decided through a consultative process with research experts from academia, leadership within the EPI clusters, and CHAI's technical advisors providing support to national and sub-national levels. The percentage of unimmunized children with DPT1 within a health catchment area was assigned a weight of three; and the amount of HTR SSA, hamlets, and BUA within a health area, a weight of two each. Finally, the number of health areas covered by slums or new settlements was assigned a weight of one. The weighted score was calculated by taking a weighted average of the indicators included in the score.

The score was calculated separately for rural and urban health areas because of the difference in settlement types and operational definitions for HTR areas in rural and urban settings. Urban health areas were defined as areas with BUA, while rural health areas were those with SSA or hamlets. Health areas with higher scores were considered more likely to contain zero-dose children. All analyses were performed using Quantum Geographical Information System (QGIS) and R statistical programming (version 3.5.1, The R Foundation for statistical computing, Vienna, Austria).

This robust approach to localizing zero-dose children can improve data-driven decision-making for immunization programs by producing reliable estimates of target populations and identifying chronically missed settlements and locations with the highest number of zero-dose and under-immunized children. In addition, it can provide immunization managers with solutions to optimize resource distribution.

Results

Outcome of analysis and mapping

Distribution of health area scores: Figure 1 provides a boxplot that shows the distribution of weighted health area scores for rural (Panel A) and urban (Panel B) health areas. Higher scores represent a higher likelihood of containing zero-dose children. There were significant variations in scores in both urban and rural health areas. The median score for rural health areas was 0.23 (interquartile range [IQR] = 0.14 - 0.34). The median score for urban health areas was 0.26 (IQR = 0.17 - 0.36) (Figure 1). The scores for urban and rural health areas are not comparable as they were generated using different methods as previously described.

Map visualization of health areas scores: Figure 2 shows health areas where zero-dose children are likely to be concentrated. Although zero-dose children are found in most regions of the country, priority health areas are more concentrated in rural areas, as shown in Figure 2b. Zero-dose hotspots are

more prominent in the Far North, North, Adamawa, East, and Southwest regions.

Trend in health area scores: Figure 3 shows the percentage of health areas within a region ranked by quintiles of their health area scores. Health areas in the highest quintile are most likely to contain zero-dose children, while those in the lowest quintile are least likely to contain zero-dose. Adamawa region had the highest percentage of health areas (~78 percent) within the highest quintile, followed by the East (50 percent), West (47 percent), and North (42 percent) regions (Figure 3).

Prioritization and characterization

Following the identification of these missed communities, CHAI supported the EPI to select 200 health areas with the largest absolute number of estimated zero-dose children across 69 districts in the ten regions of Cameroon for intervention. Of the 200 health areas identified, top 100 health areas were ranked, and 20 high-impact health areas (two health areas per region) were further prioritized for pilot intervention using a human-centered consultative approach with the support of stakeholders.¹⁴ These areas comprising an estimated 7,532¹⁵ zero-dose children represent almost one-fifth (22.3 percent) of total zero-dose children identified in the top 100 ranked health areas in Cameroon. Following initial consultations with target districts, these areas were found to align with those consistently demonstrating low vaccination coverage and access difficulties to other primary healthcare services.

The prioritized 20 health areas were then characterized through in-depth interviews to explore the five key thematic domains: demographic information, socioeconomic status, accessibility profile, communication/community engagement

preferences, and service delivery functionality. The in-depth interviews were conducted with vaccine managers at the district and health area level using a semi-structured tool designed by EPI, CHAI, and other partners to describe the different health areas.

Preliminary findings from the characterization analysis showed that 241 settlements/villages of 520 villages (46 percent) identified in the 20 health areas were poorly covered by the existing health facilities. About 33 percent (7) of health areas lacked functional cold chain equipment; 80 percent (16) have insufficient availability of health workforce; 46 percent (239) of villages/communities are poorly accessible and enclaved; 80 percent (16) of health areas lacked basic modes of transportation (bikes, bicycles, boats) needed for outreach activities; 65 percent (13) lacked electricity supply, (while the majority have unstable electricity supply, and 39 percent (8) do not have mobile network signals at all (while the majority have spotted and unstable signals). Based on the results of the characterization, health areas were grouped into three intervention clusters with a differentiated approach per cluster.¹⁶

Next steps: Advocacy

CHAI is currently supporting EPI to enhance immunization service delivery to reach more communities using context-specific and sustainable approaches. To achieve this, CHAI will be collaborating with EPI to secure buy-in from local authorities, and work with community representatives, relevant stakeholders, and other partners to develop and implement well-tailored, context-specific, and sustainable interventions to reach zero-dose children in missed communities. This approach has the potential of enhancing access to not just immunization

¹⁴ CHAI supported EPI to develop an evidence-based strategic plan to reach zero-dose children in missed communities which was endorsed by the Cameroon Ministry of Public Health.

¹⁵ using DPT-1 coverage as an indicator with DHIS2 as the data source

¹⁶ Cluster groups and number of HAs per group: Crisis affected HA (6), Non crisis zone with infrastructural and HR challenges (13), non-crisis zone with no major infrastructural or HR needs but requires capacity building and supportive supervision (1)

services, but also other primary healthcare services.

Conclusion

Reaching zero-dose children is important to improve vaccination coverage and reduce health inequities within populations by leaving no child behind. Key to this, is identifying and characterizing missed communities. Data triangulation using innovative technological approaches such as GIS with disaggregated community-level data is likely to enhance data-driven decision making and efficient use and distribution of limited resources to reach zero-dose children. Similarly, the use of geospatial analysis to enhance immunization coverage using the composite scoring system is potentially a feasible and cost-effective manner of identifying zero dose children in low resource settings¹⁷. However, the accuracy of such methods depends on the availability and reliability of local data. Therefore, it is important to train health system actors at the operational level on data collection and reporting, especially using electronic systems such as DHIS2.

Limitations

It is important to note that there are variables that we deemed appropriate to

include in the composite score but were not available at the time of analysis.

- Data on the number of healthcare workers in each health area, and the occurrence of vaccine preventable diseases outbreaks at health area level, which are indicative of limited availability and accessibility to vaccination services, were absent and so were not included in the composite score.
- Although we were aware of the different regions in conflict, data on the health areas affected by these conflicts was not available.
- Important socio-economic indicators such as educational level, family income, gender role in decision making, were not included in the score mainly because of unavailable data.

Where available, it is important to consider including these indicators in the score. In addition, updating information on the geo-location of health facilities providing vaccination services will improve the estimation of the amount of HTR settlements in each health catchment area.

This work was done in collaboration with Cameroon's Expanded Program for Immunization, the Clinton Health Access Initiative Vaccines country program, Gavi, the Vaccine Alliance, Global Vaccine's Service Delivery, and the Analytics and Implementation Research teams.

¹⁷ Chaney SC, Mechael P, Thu NM, Diallo MS, Gachen C. Every Child on the Map: A Theory of Change Framework for Improving Childhood Immunization Coverage and Equity Using Geospatial Data and Technologies. J Med Internet Res. 2021 Aug 3;23(8):e29759

Annex

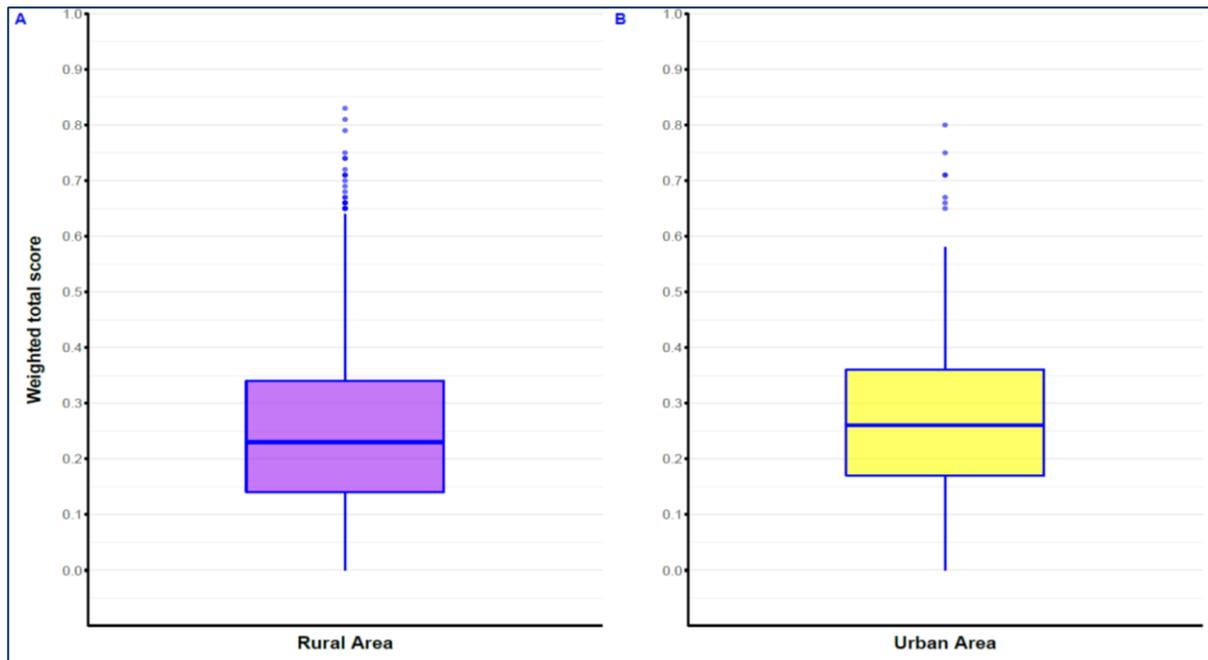


Figure 1: Box plot - distribution of weighted health area scores for rural (Panel A) and urban (Panel B) health areas.

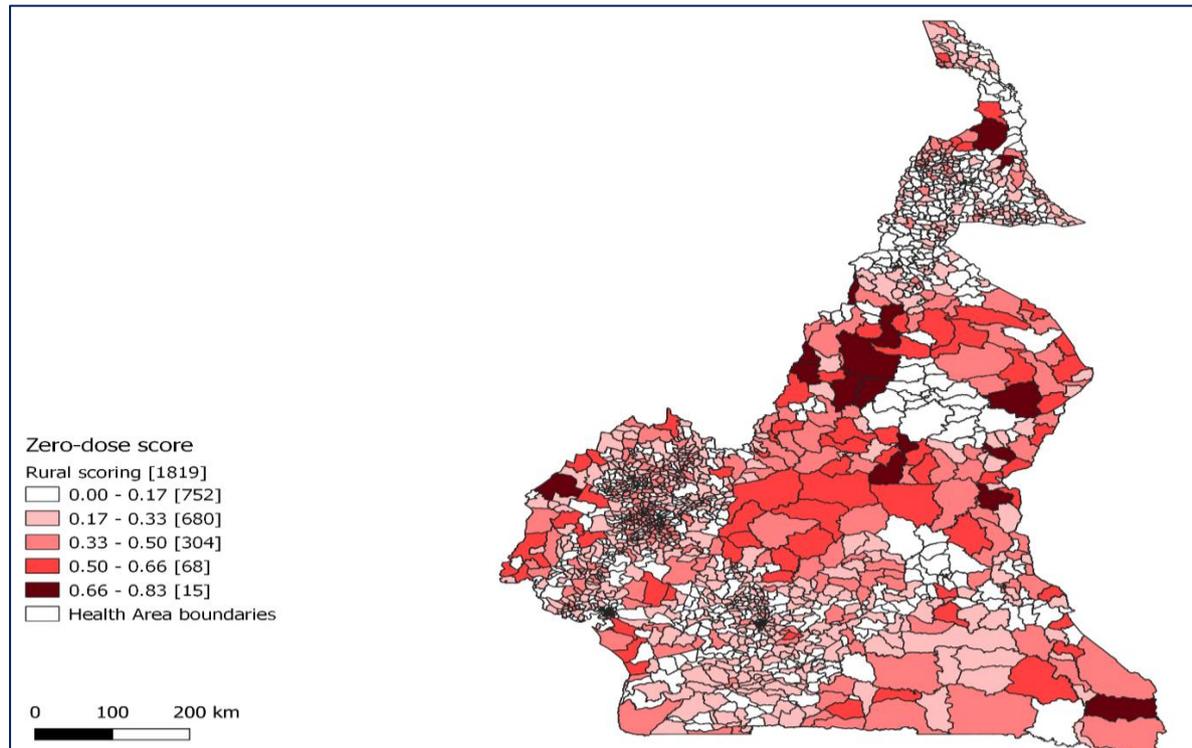


Figure 2a: Map visualization of health area scores showing locations with highest to lowest probability of finding zero-dose children.

B. Selected rural health areas

C. Selected urban health areas

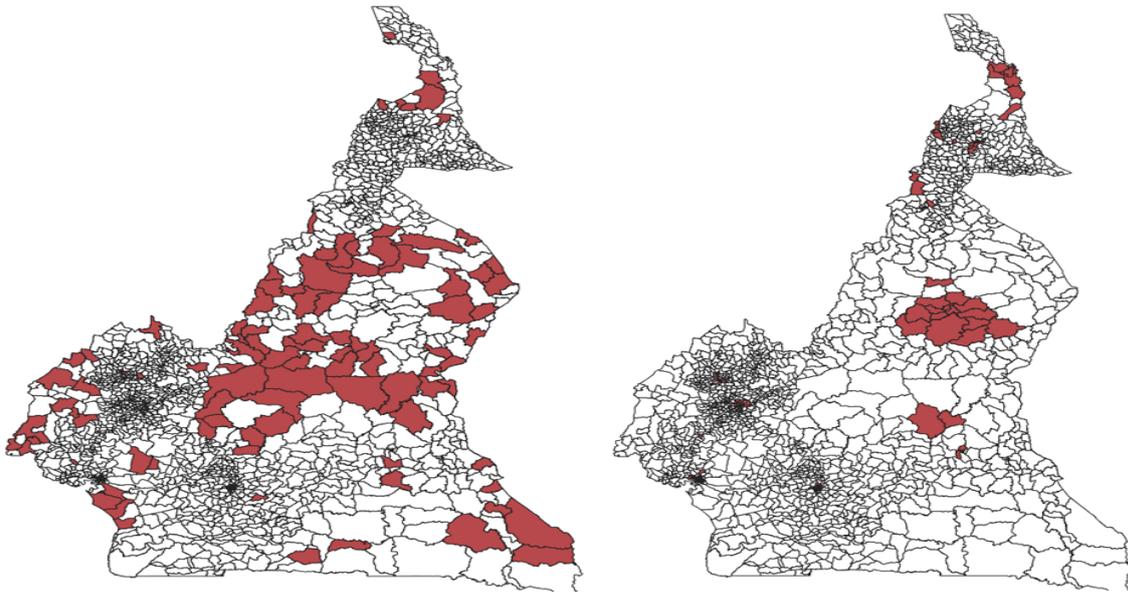


Figure 2b: Distribution of high-priority health areas in rural and urban settings in Cameroon.

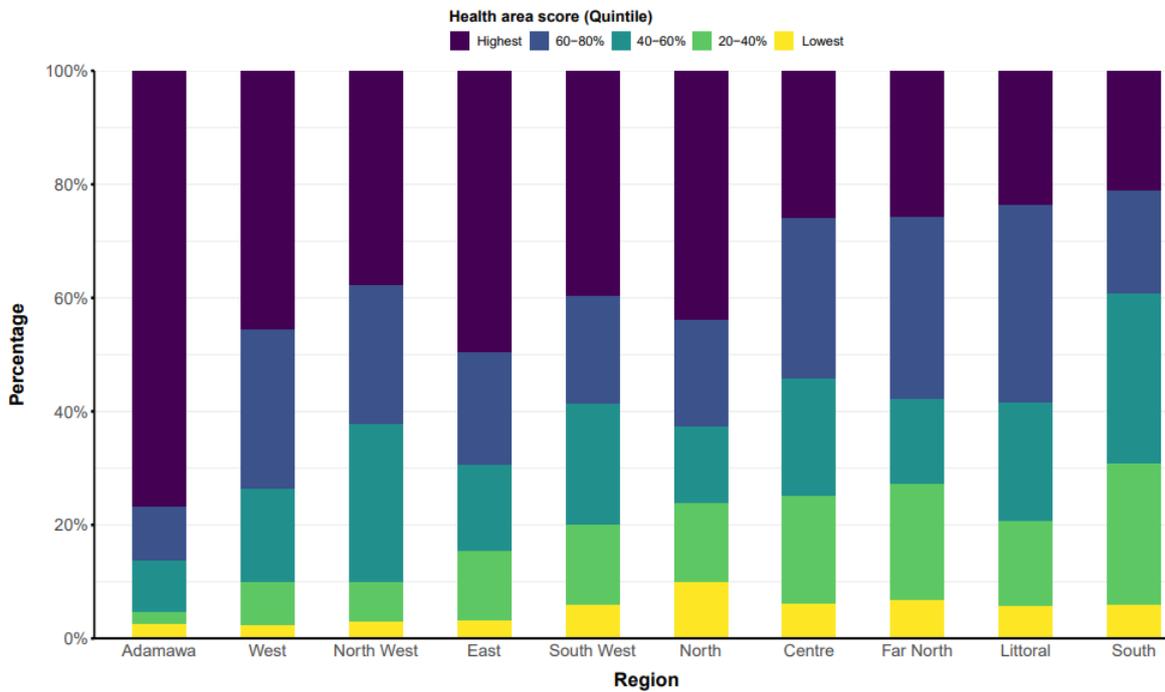


Figure 3: Regional trends in health area scores in Cameroon