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Geographic equity in essential newborn care practices in Ethiopia: a cross-sectional study

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Abstract

Background Essential newborn care is a set of measures every newborn baby needs, regardless of its birthplace. Geographic equity in essential newborn care refers to the fairness of access to newborn care across different regions. These practices vary across different social groups, but evidence on the geographic equity of newborn care in Ethiopia is scarce. We aimed to assess the geographic distribution and equity of selected essential newborn care practices (initial skin-to-skin care, delayed bathing, proper cord care, timely breastfeeding initiation, and immunizations of BCG and first-dose polio vaccines) recommended by the World Health Organization among neonates born at health facilities and homes in Ethiopia.

Methods We analyzed cross-sectional survey data from 2,493 neonates in the Performance Monitoring for Action (PMA) Ethiopia 2019–2020 survey in five regions and the Addis Ababa City Administration. The survey employed a cross-sectional study design, and the data were collected from 2019 to 2020. We studied the geographic variation of selected essential newborn care practices using Global Moran's I statistics and hot and cold spot analysis (Local Getis-Ord Gi* statistic), and the coverage of these practices were predicted for the whole country using Kriging interpolation.

Results This study showed that selected essential newborn care practices were higher among neonates in health facilities, those born in Central, Northern, Southern, and a few areas in Southwest and Northwest Ethiopia. Geographic inequities were demonstrated in delayed bathing in facility and home births, proper cord care in facility births, and first immunizations in both facility and home births. Geographic inequities were not observed for initial skin-to-skin care and timely breastfeeding initiation.

Conclusion Selected essential newborn care practices were higher among neonates born in health facilities, and the recommended essential newborn care practices were higher in Central and Northern Ethiopia. There were geographic inequities in delayed bathing and immunizations of BCG and first-dose polio vaccines among neonates born in health facilities and homes. Enhancing facility delivery, availing first vaccinations in facilities, and improving discharge counseling for mothers during antenatal, delivery, and postnatal care are crucial to ensuring geographic equity in essential newborn care in Ethiopia.

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Keywords Newborn care, Essential newborn care, Geographic equity, Ethiopia

Background

The World Health Organization (WHO) recommends that all newborns receive several essential care practices regardless of their geographic location and birthplace [1]. These practices include thermal care, such as the initial skin-to-skin care and delayed bathing, clean cord care, including application of chlorohexidine after cutting the cord, first-hour initiation of breastfeeding, and BCG and first-dose polio immunizations [2]. These essential newborn care practices enhance the health and survival of the neonate [3]. Practices can be promoted at health facilities where healthcare workers are responsible, and at home where family members or other attendants are providing the care [4].

Essential newborn care is needed for reaching the SDG 3.2 target to reduce the global neonatal mortality to 12/1000 live births or less [5]. Ethiopia, after an impressive reduction of under-five mortality before 2015, has a stagnating neonatal mortality, which was 33/1000 live births in the 2019 mini Ethiopian Demographic and Health Survey (EDHS) and the recent 2020 Ethiopia Estimates developed by the UN Inter-agency Group for Child Mortality Estimation 26/1000 live births. The survey also showed that 26% of newborns got the recommended clean cord care, 72% were initiated to breastfeeding during the first hour, and 73% got BCG and the first-dose polio immunizations. The 2016 and 2019 EDHS survey reports showed significant geographic variation of essential newborn care across regions [6, 7].

Available evidence from low-income countries also revealed geographic variations in the coverage of essential newborn care, and these practices in homes are highly affected by the culture, beliefs, and values of a given society [8–10]. Diverse topography, residence, place of delivery, and household socioeconomic status affect essential newborn care provision and outcomes. Many cultural practices in different settings also affect the provision of essential newborn care practices [11, 12].

Ethiopia's health sector development programme emphasizes achieving universal health coverage and focuses on improving neonatal and child health [13]. There is also ample evidence on the prevalence and determinants of newborn care practices (24–49%) [3, 14, 15]. However, there is a dearth of evidence on the geographic distribution of essential newborn care practices in Ethiopia. Newborn care practices are highly affected by geographic location, socioeconomic status, culture, beliefs, and values [16]. These variations may be particularly marked in settings where road and transport access are limited to access health services [17].

Understanding the geographic distribution of essential newborn care practices is vital to measure access of newborn health care [18, 19]. An analysis of the equity and geographic variation may enhance the awareness of the underlying mechanisms. However, knowledge of the geographic equity of the selected essential newborn care practices for Ethiopian babies born at health facilities and homes is limited. Therefore, we aimed to assess the geographic distribution and equity of selected essential newborn care practices recommended by the WHO, i.e., initial skin-to-skin care, delayed bathing, proper cord care, timely breastfeeding initiation, and BCG and first-dose polio vaccines among neonates born at health facilities and homes in Ethiopia. The findings of this study could inform policymakers, program planners, local administrators, and other stakeholders to use an equity lens when planning, monitoring, and evaluating newborn health programs. In addition to the general program efforts, it could help to make special efforts to target underserved groups or geographic areas.

Methods

Study design and setting

This study was done using the 2019–2020 PMA survey data that employed a cross-sectional study design. Data were collected in five Ethiopian regions: Tigray, Afar, Amhara, Oromia, the then Southern Nations, Nationalities, and Peoples' (SNNP), and the Addis Ababa city administration. These regions cover 90% of the country's total population [7]. The 2025 evidence from the Worldometer indicated that the total population of Ethiopia is 134,391,344, and 80% of the population lives in rural areas [20]. Ethiopia has a three-tiered health system: (1) primary care consisting of health posts, health centers, and primary hospitals; (2) secondary care with general hospitals and specialty clinics; and (3) tertiary care with comprehensive specialized hospitals.

Data source, sampling size determination, sampling technique and procedure

Data came from the Performance Monitoring for Action (PMA) Ethiopia 2019–2020 survey, with a two-stage cluster sampling with urban-rural and regional strata. Accordingly, the sample size was estimated to detect a 5% difference between groups of neonates defined based on place of delivery, residence, and EAs. Considering an alpha level of 0.05 and a power of 0.8, a minimum sample size of 2,500 neonates was included [21]. The study areas were all rural in Afar and all urban in Addis Ababa City Administration, while the rest were from urban and rural strata. The primary sampling units were enumeration

areas (EAs) selected with a probability proportional to the size of the regions. A total of 217 EAs were included in the sample. Data were collected at the household level by randomly selecting 35 to 42 households per EA. A centroid was created for each EA using selected household coordinates (latitude and longitude). The EA locations were randomly displaced by distance and direction for integrity reasons. Urban EAs were displaced up to five km, while rural EAs were displaced up to two km, considering the population density [22]. Shapefiles were obtained from the Central Statistical Agency [7].

Source and study population

The source populations were all neonates in the five administrative regions in Ethiopia, who were born in either health facilities or at home. The study population included all neonates who were born in randomly selected district EAs, health facilities, or at home. And all neonates who were born in the randomly selected district EAs, health facilities, or at home and who were randomly selected for inclusion were the study subjects.

Eligibility

Neonates delivered at home or in a health facility and randomly chosen for inclusion, as well as mothers' willingness to participate, were the eligibility requirements for the district EAs that were chosen at random.

Data collection and quality control

Data were collected using a standardized questionnaire on critical maternal and newborn health services provision and practices. Women's sociodemographic and reproductive characteristics, including age, education, region, religion, parity, residence, household wealth, and birth histories, were collected after informed consent from eligible pregnant or early postpartum women. Neonatal and delivery-related information was collected when the newborn babies were around seven weeks old. Details on the methods of the survey and data collection tool are available elsewhere [21].

To maintain data quality, training was given to all data collectors, field supervisors, and coordinators on interview techniques, data collection procedures, electronic data collection tools, and survey protocols. This training was supported by 3 days of field testing of the electronic data collection using the Open Data Kit. Supervisors provided on-site support and regular checks on data collectors to enhance data quality. The central data management team verified that interviews took place inside the study area using the households' registered geographic coordinates.

Outcomes

WHO recommends essential newborn care activities provided by healthcare workers, family members, or other attendants to newborns immediately, during, and after delivery [2]. The outcome variables were a selection of immediate essential newborn care practices at health facilities and homes. These were initial skin-to-skin care, delayed bathing, proper cord care, and timely breastfeeding initiation.

We also included one essential healthcare service, the BCG and first-dose polio immunizations. These practices and the service were measured based on the WHO guidelines and reported by the mothers [2]. Initial skin-to-skin care responses were coded "Yes" if the mother reported that the neonate was placed naked on the mother's chest against the skin immediately after birth and "No" if otherwise. Delayed bathing was coded "Yes" if the mother reported that washing her newborn was postponed until at least 24 h after delivery and "No" if otherwise. Proper cord care was coded "Yes" if the mother reported not applying anything except chlorohexidine on the cord stump after cutting and "No" if otherwise. Timely breastfeeding initiation was coded as "Yes" if the mother reported that she initiated breastfeeding within an hour after birth and "No" if otherwise. BCG and first-dose polio immunizations were assessed based on the mothers' responses and by checking the immunization cards. Immunization status was coded as "Yes" if BCG and the first-dose polio vaccines had been provided and "No" if otherwise.

Information was also collected on region, household wealth index quintile, maternal education, maternal age, religion, sex of the neonate, parity, and antenatal care attendance. The household wealth index was constructed using principal component analysis of household assets, categorized into quintiles from 1 = lowest to 5 = highest. Maternal education referred to the highest level of education attained and grouped into no formal education, primary level (attended grades 1–8), and secondary or higher levels (attended grades 9–12 or attended higher education or technical-professional education). We defined geographic equity as the absence of variations in selected essential newborn care practices or service provision across different geographic areas, or geographic inequity if otherwise.

Analyses

The mothers' and newborns' sociodemographic and reproductive characteristics were cross-tabulated with facility and home births as weighted percentages.

Geographic autocorrelation (Global Moran's I) was computed to assess whether the geographic distribution of essential newborn care practices was clustered, dispersed, or randomly distributed [23]. Global Moran's

I range from– 1 to 1; the negative value indicates the essential newborn care practices are dispersed, the positive values indicate the practices were clustered, and if the value is close to zero, it indicates the practices were randomly distributed. Z-score and p-values were used to either reject or accept the null hypothesis, i.e., the practices and provisions of essential newborn care were randomly distributed across the study area [24].

We used Getis-Ord statistics to measure the geographic equity of the selected interventions. The Getis-Ord General G statistics measure the degree of clustering of high or low levels of essential newborn care practices and provision of services. A higher or lower z-score value indicates the intensity of clustering [24]. It compares the local mean rate (the rates for a cluster and its nearest neighboring clusters) to the global mean rate (the rates for all clusters). A z-score and p-value are produced for each cluster. A high positive z-score and a small p-value for a feature (cluster in this case) indicate geographic clustering of high values of the practices and provision of essential newborn care (a hot spot). A low negative z-score and a small p-value indicate geographic clustering of low values of the practices and provision of essential newborn care (a cold spot). A z-score near zero indicates no apparent spatial clustering [24, 25].

A geographic interpolation tool was used to predict essential newborn care practices and service provisions in the unsampled areas based on the observed EAs. We chose ordinary Kriging as it optimizes the weights of the newborn care practice values [26]. The kriging weights are calculated in a way that gives greater weight to points closer to the point of interest than ones further away. The kriging predictor is computed to reduce the prediction error for that point.

Data analyses were performed using STATA version 18 software. Then, data were exported to ArcGIS 10.7 for geographic equity analysis. Weighted proportions of both the outcome and explanatory variables were used in all analyses.

Table 1 Sociodemographic characteristics ($n=2,493$), PMA Ethiopia 2019–2020 survey, weighted data

Variables	Place of delivery (%)	
	Health facility (*N*=1532, 53%)	Home (*N*=961, 47%)
Region		
Tigray	70	30
Afar	17	83
Amhara	57	43
Oromia	49	51
SNNP	48	52
Addis Ababa	98	2
Household wealth index		
1 Lowest	28	72
2 Lower	39	61
3 Middle	50	50
4 Higher	58	42
5 Highest	94	6
Education		
None	38	62
Primary	56	44
Secondary or higher	85	15
Age group (years)		
15–19	57	43
20–34	55	45
35–49	44	56
Religion		
Orthodox	63	37
Protestant	49	51
Muslim	47	53
Others	41	59
Sex of newborn		
Boy	54	46
Girl	53	47

SNNP = Southern Nations, Nationalities, and Peoples'

Results

Participants' characteristics

A total of 32,792 reproductive age women were evaluated for eligibility and those who were pregnant or within six weeks postpartum, permanent residents of the households, and consented to participate were included in the study. Finally, 2,581 women were eligible, 2,453 (95%) available for the study, they had 2,493 live births (40 twins).

More than half (53%) of neonates were delivered in health facilities (Table 1). Most of the newborns in Addis Ababa (98%), Tigray (70%), and Amhara (57%) were delivered in health facilities, while a high proportion of home deliveries (83%) were observed in the Afar region. Most mothers (94%) in the highest household wealth quintile gave birth at health facilities, while most mothers (72%) in the lowest wealth quintile delivered at home. Similarly, secondary or higher education levels were linked to birth in health facilities. Younger maternal age was also associated with facility delivery.

Geographic patterns in newborn care practices and service provision

The geographic distribution of initial skin-to-skin care and first hour initiation of breastfeeding was not geographically autocorrelated, implying that geographically nearby values did not tend to be similar (Table 2). Delayed bathing and immunization were geographically autocorrelated for newborns delivered at health facilities and homes, implying that geographically nearby values tended to be similar. Proper cord care was geographically

Table 2 Geographical autocorrelation results of selected essential newborn care practices among neonates born at health facility and homes, PMA Ethiopia 2019–2020 survey

Place of delivery	Type of care	Moran's index	Z score	*p*-value
Facility	Skin-to-skin care	0.002	0.154	0.877
	Delayed bathing	0.377	8.047	0.001
	Proper cord care	0.245	5.279	0.001
	Breastfeeding initiation	0.015	0.422	0.673
	Immunization	0.951	20.087	0.001
Home	Skin-to-skin care	-0.105	-1.769	0.077
	Delayed bathing	0.222	4.030	0.001
	Proper cord care	0.056	1.106	0.269
	Breastfeeding initiation	0.002	0.158	0.874
	Immunization	0.539	9.652	0.001

autocorrelated for newborns delivered at health facilities but not for newborns delivered at home.

Geographic equity of essential newborn care practices and service provisions

Overall, initial skin-to-skin care and timely breastfeeding initiation practices were randomly distributed in facility and home births, implying that these practices were equitably distributed. Delayed bathing, BCG, and first-dose polio immunizations were clustered in both delivery places, and proper cord care practice was clustered among facility deliveries, while they were randomly distributed in home births. However, variations in the absolute levels of these essential newborn care practices and provisions between facility and home births revealed geographic inequities. The Kriging interpolation proportion results of the practices revealed higher coverages in facility-born neonates compared to home births, including delayed bathing (facility: 0-100%, home: 12–86%), proper cord care (facility: 2–85%), and BCG and first-dose polio immunizations (facility: 5–95%, home: 2–66%).

A higher level of delayed bathing practice was seen in central Ethiopia for newborns delivered in health facilities (Fig. 1a) and in the northern part of the country for home deliveries (Fig. 1b). Low levels of delayed bathing were found in most areas in the west and southwestern, and a few areas in the eastern parts of the country. A higher level of proper cord care practice was found in eastern Ethiopia for health facility births. There were low levels of proper cord care practice in the country's central and southern parts. Higher levels of BCG and polio first dose immunization were identified in central and northern Ethiopia for health facility delivery (Fig. 2a) and in central and a few areas in the northern and eastern parts of the country for home deliveries (Fig. 2b). Low levels of immunization areas were seen in central Ethiopia and a few areas in southern parts of the country for facility deliveries, and western Ethiopia for home deliveries.

Geographic prediction of essential newborn care practices and service provision

Higher coverage of delayed bathing practices were predicted in central, some parts of northern, eastern, and southern Ethiopia for infants born at health facilities (Fig. 3a), and in northern and a few areas in the southern parts of the country for infants born at home (Fig. 3b). Low levels of delayed bathing were predicted in north-west and south-central parts of the country for facility births, and the north-west and central Ethiopia for home

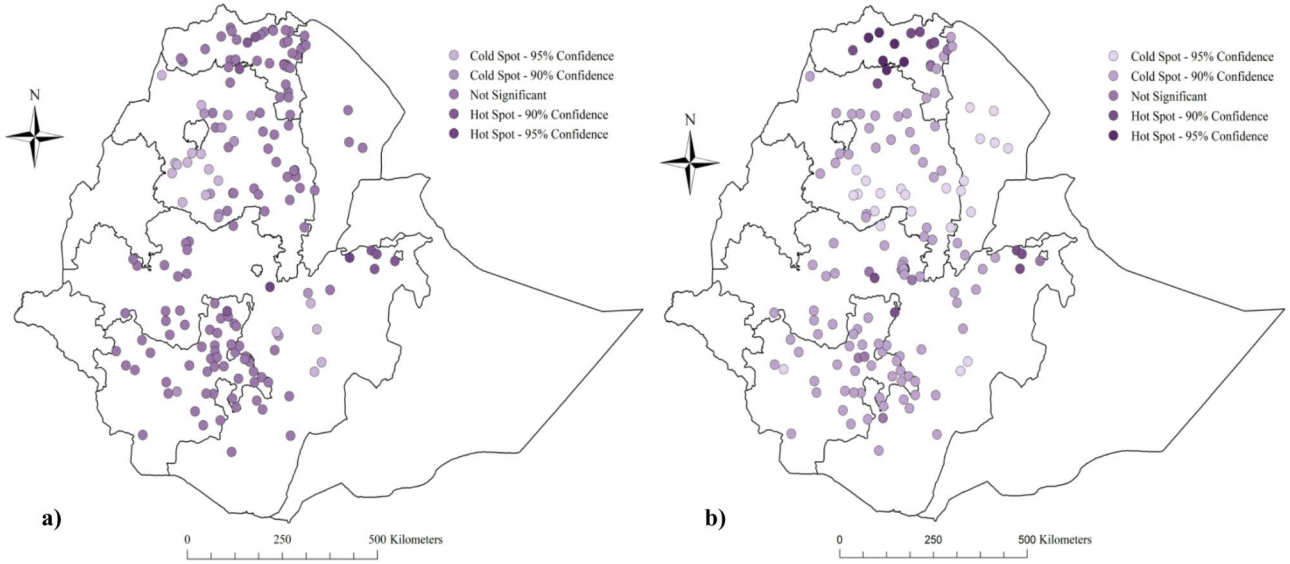

Fig. 1 Hot and cold spots of coverage of delayed bathing until 24 h after birth among facility (a) and home (b) deliveries, PMA Ethiopia 2019–2020 survey (*N* = 2,493)

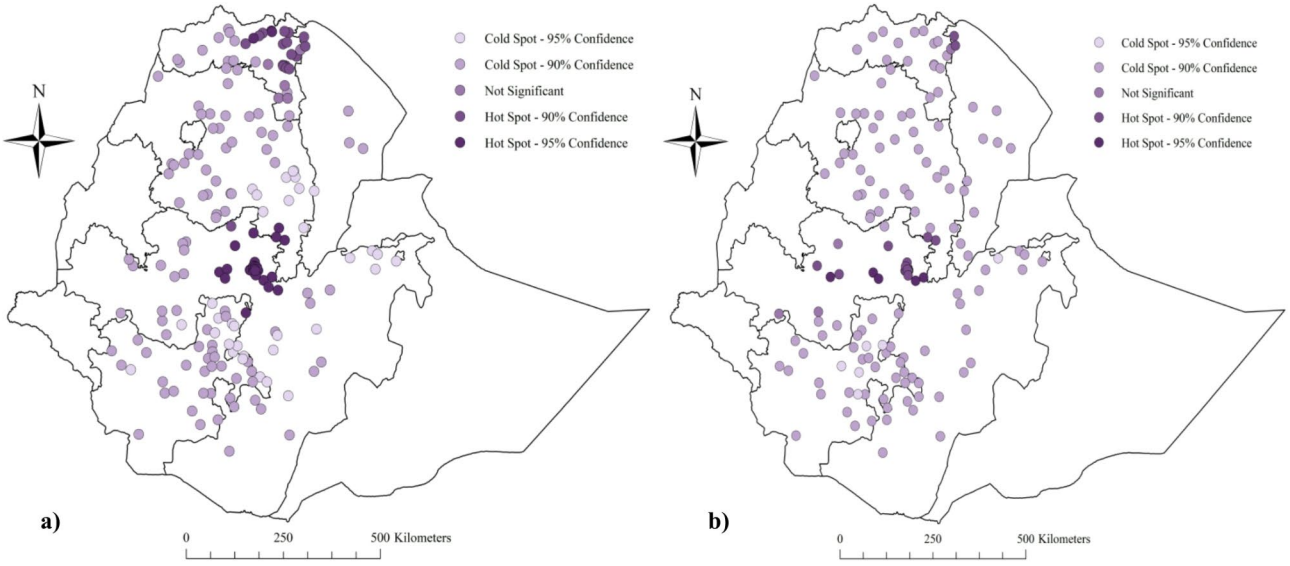

Fig. 2 Hot and cold spots of BCG and first-dose polio immunizations at time of interview among facility (**a**), and home deliveries (**b**), PMA Ethiopia 2019–2020 survey (*N* = 2,493)

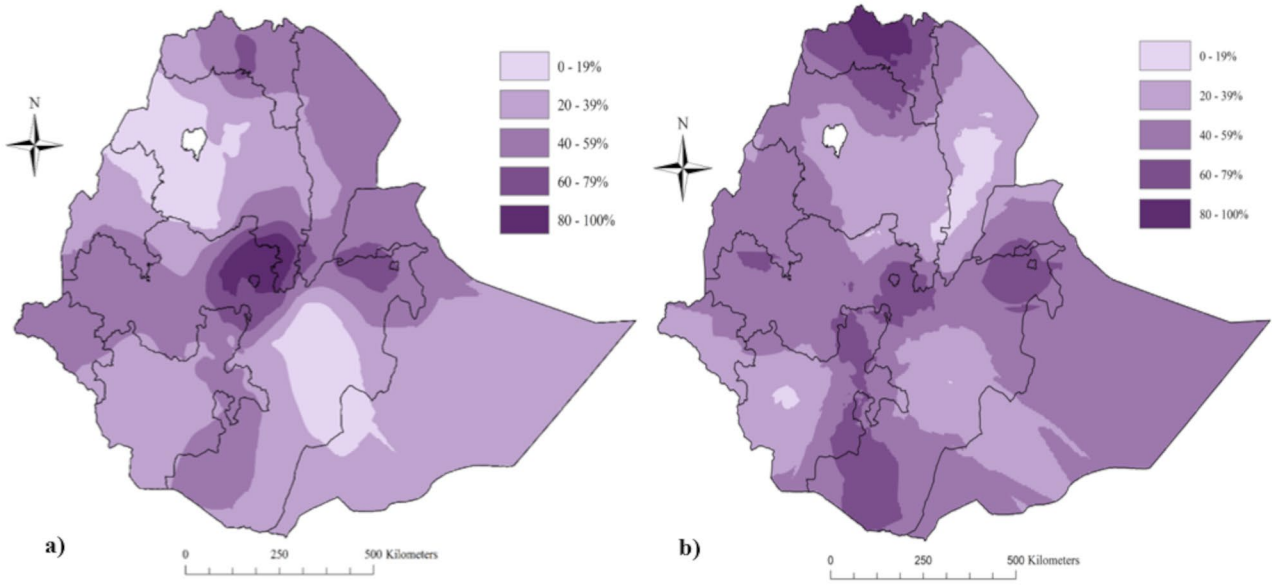

Fig. 3 Kriging interpolation of delaying bathing until 24 hours after birth among facility (**a**) and home (**b**) deliveries, PMA Ethiopia 2019-2020 survey (*N* = 2,493)

births. High levels of proper cord care were predicted for facility deliveries in the western parts of the country, while low levels were found in central, northern, and southern Ethiopia.

For facility deliveries, the BCG and first-dose polio immunization coverages were predicted high in central and north-east of Ethiopia (Fig. 4a), and for home deliveries, in the western, central and northern parts of the country (Fig. 4b). Low levels of BCG and first-dose polio immunizations were predicted in the eastern, north-east, and some parts of central and southern Ethiopia for health facility deliveries, whereas, for home deliveries, low levels were predicted in north, north-east, east and south.

Discussion

Overall, the coverage of the selected essential newborn care practices was higher among infants born in health facilities than those born at home. Some of these practices had geographic variations, including delayed

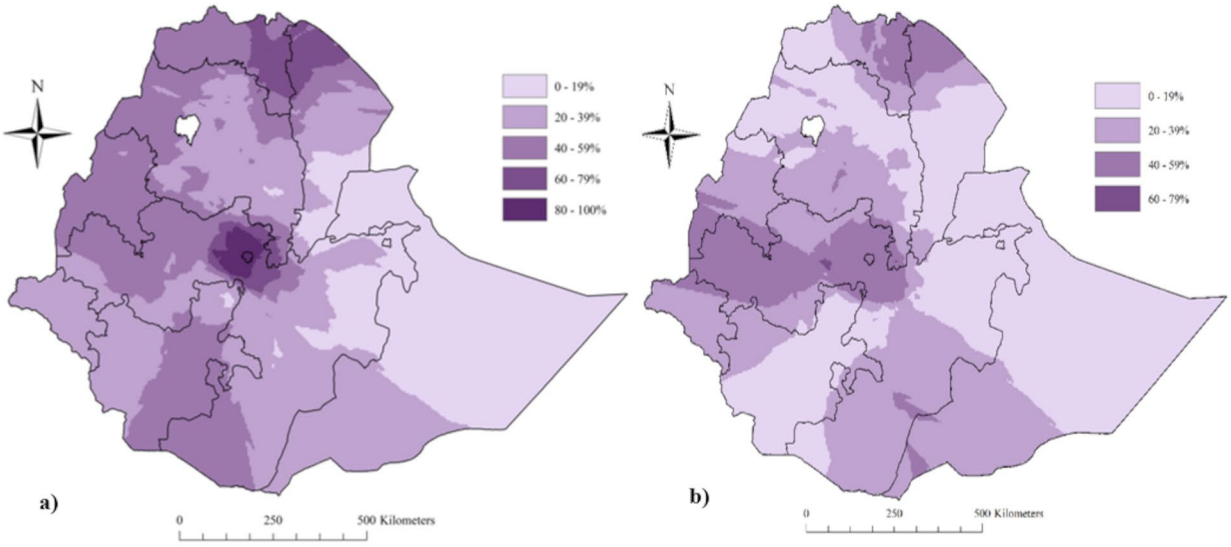

Fig. 4 Kriging interpolation of BCG and first-dose polio immunizations in six weeks after birth among facility (**a**), and home deliveries (**b**), PMA Ethiopia 2019–2020 survey (*N* = 2,493)

bathing, proper cord care, and immunizations with BCG and the first-dose polio vaccine. No geographic variations were observed for the initial skin-to-skin care and the timely initiation of breastfeeding. Delayed bathing was higher among facility-delivered neonates in central Ethiopia, while it was higher among neonates born at homes in the northern part of the country. The geographic variability of delayed bathing practices in facility births is because most families leave the facility before 24 h after birth, and may wash the baby sooner than advised once at home [27]. Proper cord care was higher in the western part of the country for neonates delivered in health facilities. BCG and first-dose polio immunizations were higher in Central and Northern Ethiopia among neonates delivered in health facilities and homes.

Every newborn needs all essential newborn care services and practices, regardless of birthplace, for survival [28, 29]. These include initial skin-to-skin care, delayed bathing until 24 h after birth for optimal thermal care, proper cord care, including not applying anything but chlorohexidine after cutting, timely breastfeeding initiation, and first immunizations with BCG and polio vaccines among neonates born in health facilities and homes. This study found geographic variations in the practices of delayed bathing, proper cord care and immunizations of BCG and first-dose polio vaccines in Ethiopia. These variations imply that essential newborn care in health facilities and home may be a challenge ensuring newborn care equity in Ethiopia.

This study showed that delaying bathing practices were higher in central Ethiopia among facility-delivered neonates, and in the northern part of the country among home deliveries. Improved healthcare system, access to health information, close supervision, and commitment of health professionals may contribute to higher frequency of delayed bathing everywhere. Reports from other Sub-Saharan African countries have also shown geographic variability in delayed bathing practices [8].

This study revealed that among facility births, proper cord care after cutting was more frequent in central Ethiopia. We have earlier shown that a small proportion of facility deliveries and a quarter of the home-delivered neonates got butter, and a few had petroleum jelly applied [30]. These malpractices in both facilities and home deliveries may increase the risk of newborn infections [9]. Previous studies in Ethiopia, Bangladesh and Pakistan have shown that proper cord care, including cleansing the cord with chlorohexidine, significantly reduces neonatal mortality [31–33]. A systematic review from low and middle-income countries showed that cord care varied by country, regions, and cultural groups, and a wide range of substances were used on the umbilical cord [10]. WHO and the Ethiopian Ministry of Health recommend appropriate cord care by keeping it dry, not applying anything, or applying chlorohexidine gel [28, 29].

There were geographic variations in the coverage of BCG and polio first dose vaccination among newborns born in health facilities and homes. The coverage was higher in central and northern parts of the country. This variation could be explained by higher proportions of facility deliveries in these areas. If born in a health facility, the probability of being vaccinated immediately after birth is higher. Furthermore, these areas may have a relatively better availability of vaccines, health facilities,

access to transport, and better supervision might contribute to this. A similar study done in four Ethiopian regions revealed that all infants born in health facilities were vaccinated for BCG and the polio first dose [34], while another study done in Niger reported that vaccinations were concentrated in some locations and distances from health facilities [35]. We considered BCG and the polio first dose vaccines to show geographic equity, unlike other studies that included measles and pentavalent vaccines.

The sample represented 90% of the population; results may be generalizable to the country. This analysis used weighted data to compensate for oversampling in some areas and adjusted data for clustering from five regions and one city administration to get correct p-values and confidence intervals, covering 90% of the population; thus, the result would be generalizable to the rest of the country. Despite the short recall period, some mothers might have difficulties in identifying and reporting some of the newborn care practices. Two in five mothers did not have any formal education, which could reduce their ability to understand some of the more technical questions. However, training was given to data collectors, field supervisors, and coordinators on appropriate interviewing techniques and data collection procedures to enhance mothers' understanding of such questions. Thus, these limitations will not affect the reliability and validity of our data and the generalizability of our findings.

Conclusion

The coverage of the recommended essential newborn care practices was relatively better in Central and Northern Ethiopia. Still, there were geographic inequities in delayed bathing and immunizations of BCG and first-dose polio vaccines among neonates born in health facilities and homes. Therefore, enhancing facility delivery through the existing health system across the continuum of care, availing birth dose vaccines for 24 h and seven days with proper linkage to the nearest facilities for immunization services, and enhancing proper counseling services for mothers across the touch-points including before discharge, so that they can keep practicing the recommended essential newborn practices once they are at home are crucial to ensure geographic equity in Ethiopia.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12887-025-05645-1.

Supplementary Material 1

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Author contributions

TGD, KA, LÅP, DB, AD, TG, SL and SS contributed to the conceptualization of the study, crafting the research questions, protocol development and analysis plan. TGD analysed and interpreted the data and drafted the manuscript. TGD, LÅP, JS, KA, DB, AD, TG, GT, SL, AT, ZA, SS and MZ have substantially revised the manuscript. All authors read and approved the final manuscript.

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Data availability

The PMA dataset used in our analyses is open access and available at https://www.pmadata.org/countries/ethiopia.

Declarations

Ethics approval and consent to participate

All study procedures adhered to the principles outlined in the Declaration of Helsinki and received approval from the Institutional Review Boards of Addis Ababa University, College of Health Sciences (AAU/CHS) (Ref: AAUMF 01–008) and the Johns Hopkins University Bloomberg School of Public Health (JHSPH) (FWA00000287).

The study participants were approached individually, and information was provided regarding the purpose of the study, confidentiality of the study, and their right to participate or withdraw from the study. Written informed consent was secured from the study participants, and assent was obtained from their partner or family members for those mothers whose ages were below 18 years.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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