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Research Article

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Assessing Spatial Variations and Associated Factors of Postnatal Newborn Care Within the First Two Days of The Postpartum Period in Ethiopia Using 2019 Mini Demographic and Health Survey: Geographically Weighted Regression and Multilevel Analysis

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Abstract

Background

Worldwide, many newborns die in the first month of life, with most deaths happening in low- or middle-income countries. Ethiopia continues to have one of the highest neonatal mortality rates in the world, it accounts for about half of the under-five mortality. Over 70% of deaths have been prevented if appropriate, essential newborn care had been provided, particularly the first two days of postnatal checkups. The study aimed to determine the spatial distribution and possible determinants of postnatal newborn care within two days of the postpartum period in Ethiopia.

Methods

Ethiopia Mini Demographic and Health Survey (EMDHS) 2019 was utilized, and a total weighted sample of 2,105 women aged 15–49 who gave birth in the two years preceding the survey were included. ArcGIS version 10.7 and SaTScan version 9.6 software were used. Multilevel Mixed effect analysis was done by STATA version 14 software. Bivariate analysis was done and variables with a p value<0.2 were issued for multilevel multivariable logistic regression.

Result

The overall prevalence of postnatal newborn care was 39.6% and the spatial distribution of newborn care was not random. Institutional delivery (AOR; 14.82 (10.07, 21.79) first ANC checkup within the first trimester (AOR 1.42(1.02, 1.96)). Maternal media exposure (AOR; 2.9(1.99, 4.23), ANC visit four & above (AOR; 2.02(1.06, 3.88)) were variables significantly associated with newborn care.

Conclusion

This study revealed the low practice of postnatal newborn care practice in Ethiopia. Media exposure, having four or more ANC visits, and institutional delivery and timing of the first ANC visit in the first trimester were positively associated with the practice of postnatal checkups of the newborn. Therefore, health education programs regarding the value of ANC visits and institutional delivery should be performed, which have a critical role in inspiring mothers to take their newborns for postnatal checkups after birth.

Abbreviations

AICc: Akaike's Information Criterion
PNNC: Postnatal Newborn Care
AOR: Adjusted Odds Ratio
EAs: Enumeration Areas
MEDHS: Ethiopian Mini Demographic and Health Survey
ICC: Intraclass Correlation
CSA: Central Statistical Agency
LLR: Log-likelihood Ratio
MOR: Median Odds Ratio
CI: Confidence Interval
OLS: Ordinary Least Square
PCV: Proportional Change in Variance
SNNPR: Southern Nations, Nationalities and Peoples' Region
ANC: Antenatal Care
PNC: Postnatal Care
ENC: Essential Newborn Care
WHO: World Health Organization
GWR: Geographically Weighted Regression

Keywords: Postnatal Checkup, Newborn, MEDHS, PNC, Ethiopia

1. Introduction

According to guidelines from UNICEF and the World Health Organization (WHO), even if everything seems to be going well, mothers who give birth in health institutions should have both themselves and their infants checked for issues within 24 hours of the birth and given an appointment to return for additional postnatal care [1,2]. It is also mandatory to be counseled to return right away if they notice any danger signs [3]. If the mother gives birth at home, the first postpartum communication needs to take place as soon as feasible, preferably within 24 hours of the birth. In general, it is advised that all mothers and their babies undergo three further postpartum examinations at least three times: on day three (48–72 hours), between days 7–14 after giving birth, and at six weeks after giving birth [2,4]. Every year, around 1.16 million African babies within their first 28 days of life. The poorest and most disadvantaged communities are disproportionately affected by neonatal mortality and associated health challenges, especially in South Asia and Sub-Saharan Africa. Most neonatal mortality in developing countries is caused by inadequate intrapartum and early newborn care protocols [3,5,6].

Around three-quarters of all newborn deaths occur within the first week of life, and the risk of death peaks in the first 24 hours of birth, when over half of deaths occur [7]. It is anticipated that straightforward, inexpensive measures might reduce around two-thirds of newborn deaths. The newborns are susceptible to many illnesses even when their birth weight is normal [3,8]. For newborns, the majority of health issues pose a risk to their lives. WHO stated that "a habitual practice has been designated as indispensable, and these include essential newborn care, which minimizes neonatal morbidity and mortality." Essential newborn care (ENC) is defined as a strategic approach planned to improve the health of newborns through interventions before, during, and after pregnancy, immediately after birth, and during the postnatal period" as well [2,9]. Essential newborn care (ENC) is a set of benchmarks for every neonate warrants regardless of their place of delivery [10]. The immediate eradication of the highlighted cause and the improvement of their nutritional condition through essential newborn care is a cost-effective intervention that enhances both mother and neonatal health [4].

Delaying the cord clamping, thoroughly cleaning the newborn, checking their breathing, making skin-to-skin contact, and early initiation of breastfeeding are all examples of immediate newborn care [8,11]. The practice of caring for newborns is broadly divided into; thermal care, evaluation of health issues, resuscitation when necessary, recognition and response to danger signs, assistance for breast-feeding, nurturing care, infection control, and timely and appropriate referral when needed [12]. The first month after giving birth is typically a life-threatening moment for both mother and baby, yet it is also the time when mothers and babies are least likely to receive the kind of skilled medical care they need. Therefore, providing appropriate postnatal care is essential to preserving the health of both the mother and the child, especially in poor economic countries like Ethiopia, where maternal and child death is common [13,14]. Identification of those factors and maintaining the possible likely interventions can enable postnatal newborn care utilization, thus reducing neonatal mortality as well. As Ethiopia continues to

be one of the countries with the highest rates of maternal and infant death worldwide, there is no recent research has been done to date to clarify and convince about the elements that support or obstruct postnatal care checkups at the national level, more than ever based on the recent evidence. Therefore, this study aimed to assess the spatial distribution and factors associated with postnatal newborn care as well as explore the proposed intervention in Ethiopia based on a mini-EDHS report.

2. Methods

2.1. Study Design, Setting, and Period

In this analysis, we employed Secondary data analysis based on the 2019 Ethiopia Mini Demographic and Health Survey (2019, EMDHS) data. The Ethiopian Mini-demographic Health Survey is the second EMDHS and the fifth Demographic Health Survey executed in Ethiopia. The EMDHS data survey was conducted from March 21 to June 28, 2019. Ethiopia is Administratively, divided into nine regional states, which are; Afar, Benishangul-Gumuz, Amhara, Gambela, Oromia, Somali, Harari, Southern Nations, Nationalities, and People's Region (SNNP), and Tigray regions with the two city administrations (Addis Ababa and Dire-Dawa) [15].

2.2. Data Source, Sample Size, Sampling Procedure, and Study Population

A cluster sampling technique with two-stage stratified sampling was employed using the 2007 Population and Housing Census (PHC) as a sampling frame. Each region was stratified into urban and rural areas, yielding 21 sampling strata. Samples of EAs were selected independently in each stratum in two stages. Sample allocation has been employed through an equal allocation where 25 EAs are selected from eight regions to ensure the survey precision is equivalent among regions. But, from the three larger regions, Oromia, SNNPR, and Amhara from each 35 EAs were selected. A total of 305 EAs with 212 in rural areas and 93 in urban areas were selected in the first stage with a probability proportional to the Enumeration Area size [15]. A fixed number of 30 households per cluster were selected in the second stage of selection, with an equal probability of systematic selection. The study was conducted based on EMDHS data by accessing the DHS program's official database, www.measuredhs.com. The women's data set or individual record (IR) data was employed and women within the two-year postpartum period preceding the survey were included, this was done after permission had been obtained through an online request by explaining and justifying the purpose of the study. All women aged 15–49 who had a birth in the 2 years preceding the survey in the selected enumeration areas (EAs) were our study population. The study population was determined by using the most recent live births of interviewed mothers in the 2 years preceding the survey. This means keeping the variable midx_1 = 1 and keeping the variable b19<24 gives the total weighted sample of 2,105 births included in the study. (Figure 1). Of these, 553 were urban residents, and 1,552 resided in rural residences [15]. All Postpartum period women with recent births were included whereas those women who have cesarean (CS) births were excluded from the final analysis because they were more likely to receive PNC checkup.

2.3. Variables of The Study

2.3.1. Dependent Variable

Postnatal check for newborns within two days of the postpartum period (Yes/No). It is a compound variable measured by Five components of postnatal checks; i.e cord examined (m78a = 1), the temperature measured (m78b = 1), counseling on danger signs (m78c = 1), counseling on breastfeeding (m78d = 1) and observation of breastfeeding (m78e = 1) [15]. Then the outcome variable was dichotomized into participants whose newborn missed at least one of the five components (signal functions) not performed within 2 days after birth considered as not having newborn care and participants with at least two components out of the five components considered as having newborn care practice within two days of the post-partum period.

2.3.2. Independent Variables

women were nested within the cluster, and two levels of independent variables were considered. At level-1 contained individual-level variables such as age of women, educational level, marital status, religion, media exposure, number of under-five children per household, wealth index, region, residence, timing of antenatal care start, number of ANC visits, antenatal care at the government health facility, place of delivery, twin's child, sex of the child, child birth order, and sex of the household head were included. At level 2, the community-level variables were considered; which were; region, residence, community media exposure, community education level, and community poverty level.

2.4. Data Management and Analysis

Data extraction, keeping the important variables, coding, and further analysis were employed using Stata 16. Sample Weighting (by generated iw = wgt) was done to warrant the data representativeness, as well as to consider the non-response rates and to get suitable statistical estimates. The samples were taken using a multistage sampling technique, and the intra-class correlation coefficient (ICC) was estimated to assess the clustering effect, then we employed mixed-effect logistic regression analysis. The proportion of change in variance (PCV) measures the proportion of the total observed individual variation that is attributable to the between-cluster variations [16]. The median odds ratio (MOR) measures the value between high and low-risk clusters (EAs). Bi-variable mixed-effect multilevel logistic regression analysis was done first to selecting variables for multivariable analysis and those variables with P<0.2 in the bi-variable analysis were included to multivariable analysis. Model fitness was checked by using deviance and the model with the lowest deviance was considered as the best-fit model. Furthermore, AORs with 95% CIs were calculated, and variables with P<0.05 on multivariable mixed-effect analysis were considered statistically significant predictors of postnatal newborn care.

2.5. Spatial Data Analysis

Spatial analysis was conducted using Arc GIS 10.7 and SaTScan 9.6 statistical software. Global spatial autocorrelations to ascertain

the pattern of whether PNNCs were clustered, dispersed, or random across the country, has been employed using the global Moran I statistic [17]. Empirical Kriging spatial interpolation was used to predict the magnitude of PNNCs in un-sampled or un-measured areas based on the values from sampled measurements. Getis-Ord Gi* statistical hot spot analysis was used to identify significant hot spot areas (which have higher rates of PNNCs) and cold spot areas (which have lower rates of PNNCs). From the time when the outcome variable was binary outcome, we used Bernoulli-based spatial scan statistical analysis to detect statistically significant spatial clusters using SaT-Scan 9.6. Whether there is newborn care (yes=1) or not (No=0). The Log-likelihood ratio statistic was applied to determine whether the number of observed cases within the potential cluster was significantly higher or not. From the SaT-SCan output, Primary and secondary clusters were identified with the respective P-values. This was ranked using LLRs based on the 999 Monte Carlo replications technique. Areas with the highest LLRs and with significant P-values were considered as high-risk clusters, however, the spatial window with the highest LLR was defined as the primary cluster spatial window as well.

3. Results

3.1. Socio-Demographic Characteristics of Respondents

In this study, a total sample of 2105 newborns were included and those 1084(51.49%) were males. Among the Newborn mothers, the majority (46.44%) had no formal education and 39.92% had primary education. Thirty-six percent were Muslim and 35.76% were Orthodox religions. Most of the 1552(73.73 %) and 39.19% were residing in the rural residence and from the Oromia region respectively. The majority (94.17 %) were married, and 86.64%were from male-headed households (Table 1).

Variables	Frequency	Percentage
Age		
15-20	180	8.56
21-34	1538	73.08
35-49	387	18.36
Marital status		
Currently not married	123	5.83
Currently married	1982	5.83
Educational status		
No education	978	46.44
Primary education	840	39.92
Secondary education	182	8.65
Higher level education	105	4.98
Religions		
Muslim	758	36.02
Orthodox	753	35.76
Protestant	755	26.39
Others	39	1.83
Residence		
Urban	553	26.27
Rural	1552	73.73
Region		
Tigray	155	7.38
Afar	32	1.49
Amhara	433	20.56
Oromia	825	39.19
Somali	132	6.28
Benishangul	24	1.15
SNNPR	411	19.55
Gambela	10	0.48
Harari	6	0.28
Addis Ababa	64	3.04
Dire-Dawa	13	0.60

Media exposure		
Yes	747	35.46
No	1358	64.54
Number of under five children		
No	66	3.13
One to two	1771	84.17
Three and above	267	12.70
Community women's education level		
Low	955	45.36
High	1150	54.64
Community media exposure		
Low	932	44.27
High	1773	55.73
Community poverty level		
Low	1091	51.81
High	1014	48.19

Table 1: Background Characteristics of Study Participants, Ethiopia, MEDHS 2019

3.2. Obstetric, Reproductive Health, and Facility-Related Factors

Regarding ANC visits, the majority of 1773(88.98%) had one to two visits and 62.80% were visited within the second trimester and above ANC visits as well. About 1171 (54.24%) mothers give birth at health facilities. Moreover, 1772(84.17%) had less than two under-five children in the household (Table 2).

Variables	Frequency	Percentage
Place of delivery		
Home	968	45.98
Health facility	1137	54.02
Timing of first ANC visit		
Within the first trimester	581	37.20
Second trimester and above	981	62.80
Number of ANC visit		
One-two	1873	88.98
Three	120	5.71
Four and above	112	5.31
Birth order		
First order	500	23.75
Two-three	721	34.26
Fur-five	446	21.17
Six and above	438	20.82

Table 2: Obstetric and Reproductive Health-Related Characteristics of Study Participants, Ethiopia, MEDHS 2019

3.3. Spatial Distribution (Projection) of Postnatal Newborn Care in Ethiopia

A total of 305 clusters were considered for the spatial analysis of postnatal newborn care in Ethiopia. On the map, each point represents one enumeration area with the proportion of postnatal newborn care in each cluster. The green color of the point on the map represents a high proportion of newborn care in the enumeration area whereas the red color indicates an enumeration area with a low proportion of newborn care. A higher proportion of newborn care was found in Tigray, Amhara, and some parts of Benishangul Gumuze. On the other hand, Somali and Oromia, SNNPR, specifically the border areas between (Amhara and Afar, Oromia and SNNPR) were characterized by a low proportion of newborn care within two days of postpartum period "Fig 1".

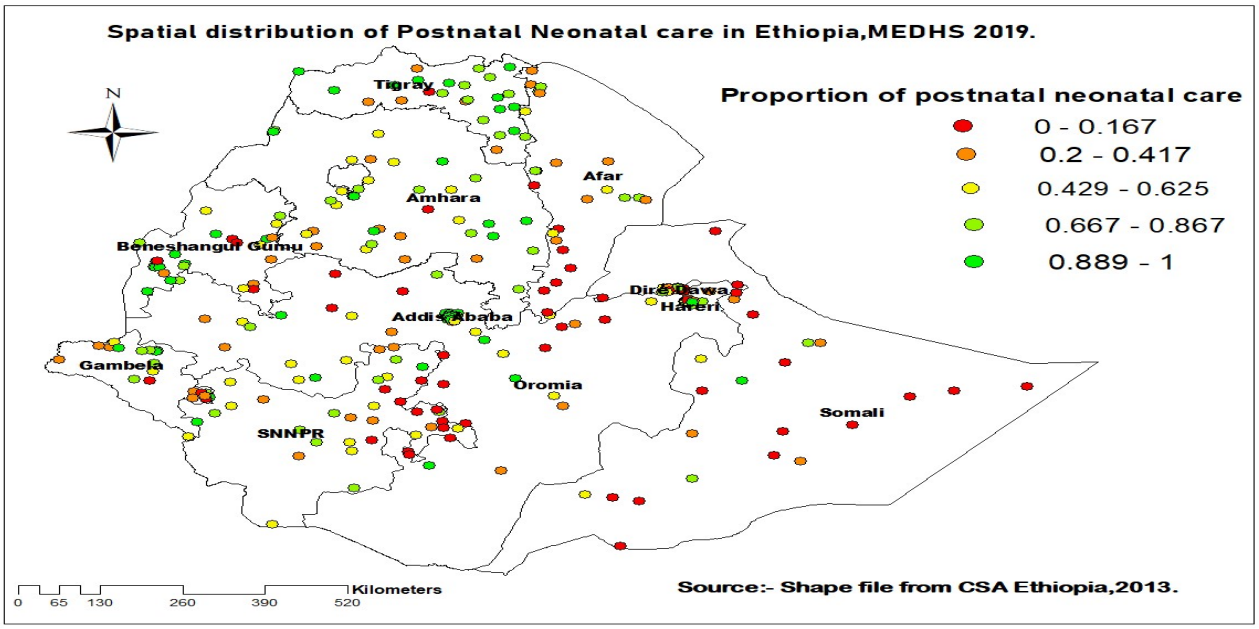

Figure 1: Spatial Distribution (Projection) In Ethiopia Using 2019 Medhs Data, Map Produced Using Arcgis Version 10.7

3.4. Spatial Global Autocorrelation

The spatial analysis has shown that the spatial distribution of postnatal newborn checks significantly varied across the country, with Global Moran's I value of 0.25 ($p<0.001$). The clustered patterns (on the right sides) showed that a high rate of postnatal newborn care was observed. A z score of 10.08 indicated that there is less than 1% likelihood that this clustered pattern could be due to the result of chance "Fig 2".

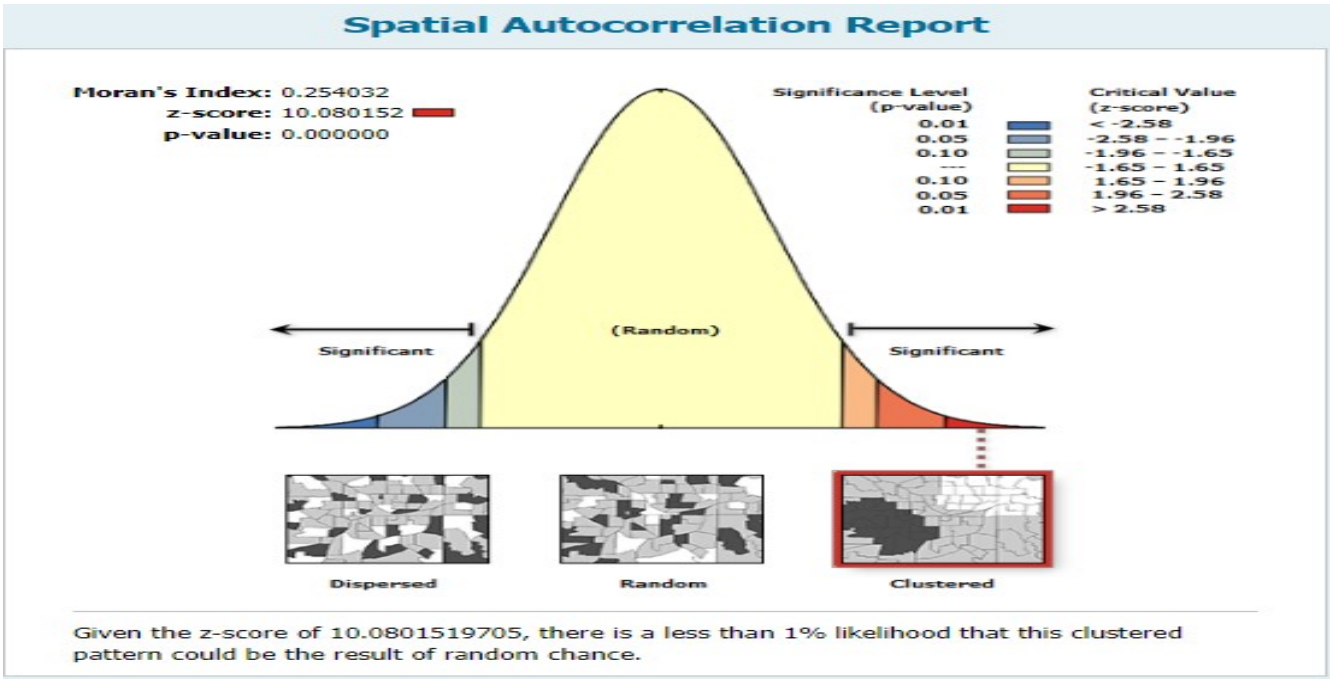

Figure 2: Spatial Autocorrelation of Postnatal Newborn care in Ethiopia, MEDHS 2019

3.5. Hot Spot and Cold Spot Analysis

Hot spot analysis was done to ascertain areas with a high and low probability for postnatal newborn care within two days of the postpartum period. The red color indicates areas with a high probability of postnatal newborn care practice like Tigray, Amhara, Benishangul Gumuze, Gambella, and Addis Ababa. On the other hand, the blue color indicates postnatal newborn care practice is less likely performed or the cold spot areas. "Fig 3".

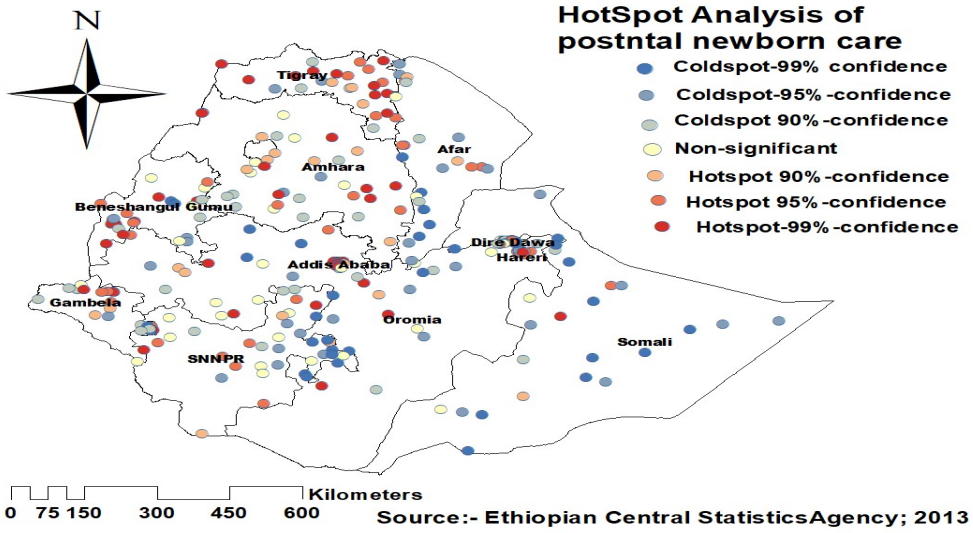

Figure 3: Hotspot and Colds Pot Area of Postnatal Newborn Care in Ethiopia, MEDHS 2019

3.6. Kriging Spatial Interpolation (Prediction)

Based on Kriging interpolation the possibility of postnatal newborn care practice was increasing while we moved from the red- to the green-colored areas. The red and semi-red color predicts less possibility of postnatal newborn care practice and the green color predicts high possibilities areas of postnatal newborn care. Tigray, North West Amhara, Addis Ababa, Harari, and Southeast Benishangul Gumuze were areas of highly predicted practice of postnatal newborn care. On the other hand, major Eastern Somali, southwest of Oromia, southern part of Afar, and Eastern part of SNNPR and southern Harari predicted fewer possibilities for postnatal newborn care practice (Figure 4)

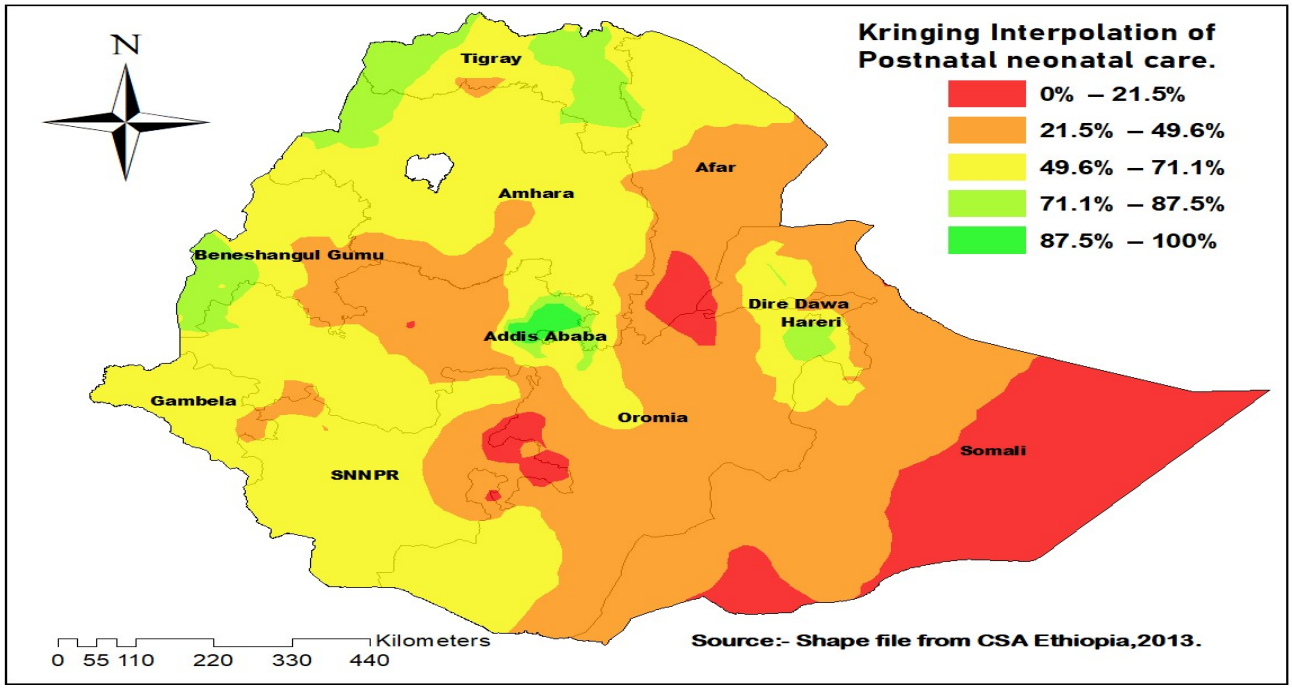

Figure 4: Kriging Interpolation of Postnatal Newborn Care in Ethiopia, MEDHS 2019

Figure (5). shows the SaTScan analysis. Of the total 305 clusters included, 129 significant clusters were identified. Of these, 23 significant clusters were primary (most likely), and the rest were secondary clusters. The primary-cluster spatial window was located in Tigray, Northwest and central Amhara, western Benishangul Gumuz, Oromia and SNNPR regions centered at 9.066209 N, 38.754639 E, with 16.92 km radius and relative risk (RR) of 1.98, as well as LLR of 59.37 (P<0.001). This can be interpreted, as Reproductive-age women who were found in the SaTScan window were 1.98 times more likely to have postnatal **newborn care** as compared to those outside the spatial window (Table 3).

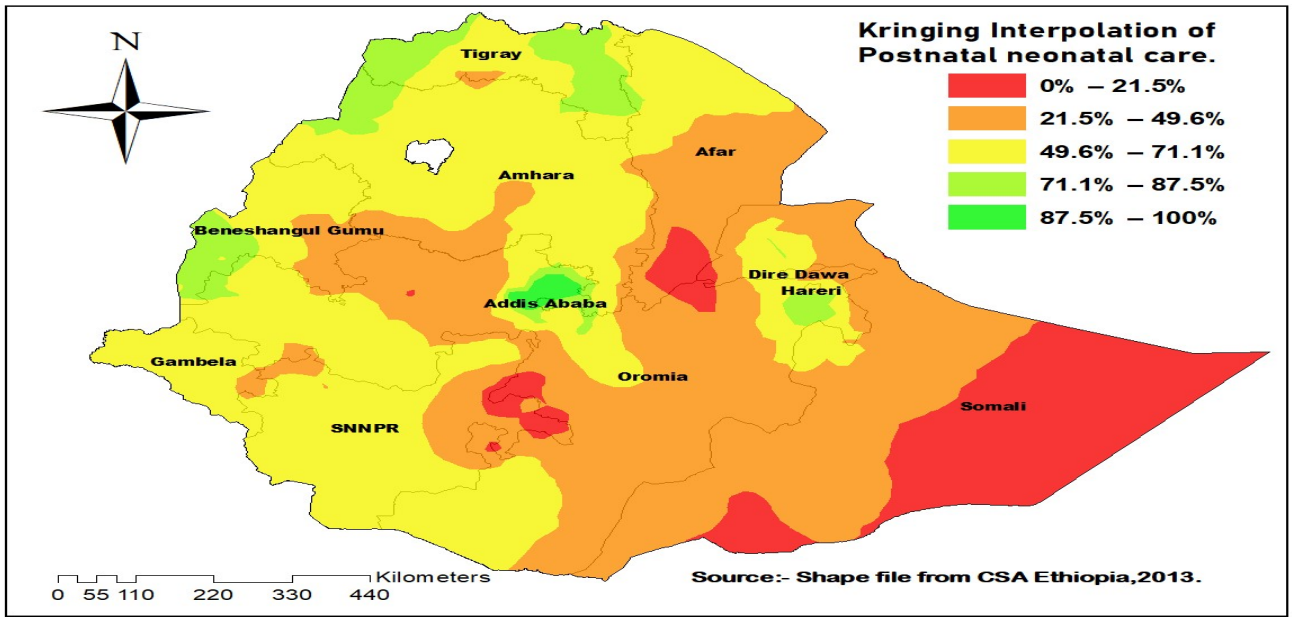

Figure 5: SaTScan Analysis Results of Postnatal Newborn care, in Ethiopia 2019

Window (Clusters)	Enumeration area(cluster) identified	Coordinates/ Radius	Population	Case	RR	LLR	P-Value
Radius	Population	Case	Case	Case	P-Value		
1*(23)	256, 265, 266, 257, 258, 263, 267, 264, 262, 261, 260, 273, 276, 259,268, 275, 271, 270, 269, 272, 277, 279, 274	(9.066209 N, 38.754639 E) / 16.92 km	102	100	1.98	59.23	<0.001
2(38)	4, 21, 22, 55, 85, 8, 9, 6, 1, 56, 7, 13, 84, 12, 82, 11, 83, 2, 14,10, 57, 16, 74, 59, 23, 78, 54, 17, 81, 75, 5, 15, 53, 3, 58, 25, 20, 165	(14.287308 N, 36.604656 E) / 348.01 km	262	189	1.47	25.35	<0.001
3(37)	21, 22, 4, 8, 9, 56, 1, 55, 85, 6, 7, 13, 84, 82, 12, 83, 11, 2, 14,57, 10, 78, 23, 59, 16, 74, 17, 54, 5, 81, 75, 3, 58, 15, 53, 20, 25	(13.881625 N, 37.111279 E) / 279.70 km	258	186	1.47	24.8	<0.001
4(21)	170, 155, 154, 86, 152, 147, 153, 151, 157, 156, 150, 149, 118, 146, 218, 211, 207, 229, 230, 208, 209	(9.532762 N, 34.455097 E) / 144.63 km	146	105	1.43	13.05	<0.001
5(9)	250, 248, 249, 255, 247, 245, 252, 244, 241	(9.227458 N, 42.199757 E) / 11.17 km	66	53	1.57	11.87	0.014
6(1)	148	(10.660500 N, 36.154667 E) / 0 km	14	14	1.94	9.23	0.02
***= significant primary cluster; RR=relative risk; LLR=log-likelihood ratio**							

Table 3: Primary and Secondary SaTScan Analysis Result of Postnatal Newborn care in Ethiopia; MEDHS 2019

3.7. Individual and Community-Level Determinants of Postnatal Newborn Care

3.7.1. The Random Effect Analysis Result

In the null model, the ICC indicated that 46% of the total variability for postnatal newborn care was due to differences between clusters while the remaining unexplained 54% of the total variability of postnatal newborn care was attributable to the individual differences. Moreover, the MOR was 1.91 (95% CI: 1.02, 4.17) in the null model, which indicated that there was variation in postnatal newborn care between clusters. If we randomly select two women from different clusters, if we transfer women from low postnatal newborn care clusters to higher postnatal newborn care clusters, they could have 1.91 times higher odds of having postnatal newborn care. The PCV in the final model was 55%, it showed that about 55% of the variability in postnatal newborn care was explained by the final full model (a model with individual and community-level variables). We used Deviance to compare the best-fitted models and model three (3) with the lowest deviance value was the best-fitted model (Table 4).

3.7.2. The Fixed Effect Analysis Result

In the multivariable multilevel logistic regression analysis place of delivery, timing of first ANC visit, media exposure, and number of ANC visits, were significantly associated with postnatal newborn care. Mothers who gave birth in a health facility had (AOR; 14.82 (10.07, 21.79) times higher odds of having postnatal newborn care than those women who give birth (deliver) at Home. The odds of postnatal newborn care among women who have their first ANC check-up in the first trimester were (AOR 1.42(1.02, 1.96)) times higher than those starting in the second trimester and above. Mothers who had media exposure were (AOR; 2.9(1.99, 4.23)) times more likely to have postnatal newborn care as compared with their counterparts. Women who had four & above ANC visit were (AOR; 2.02(1.06, 3.88)) times higher odds of having postnatal newborn care than women who have one or two ANC visits. Women from communities with high media exposure had (AOR = 1.89(1.46, 4.77)) times higher odds of postnatal newborn care as compared to women from a community with low media exposure.

Variables	Null model	Model 1	Model 2	Model 3
Individual level factors				
Marital status				
Never in union		1		1
Married		3.24(1.61, 9.98)		2.59(0.59, 7.86)
Others		1.33(0.59, 3.03)		1.25(0.55, 2.86)
Mother education				
No education		1		1
Primary education		1.205(0.83, 1.75)		1.34(0.92,1.95)
Secondary education		0.79(0.44, 1.42)		0.86(0.48, 1.56)
Higher education		0.93(0.42, 2.04)		0.92(0.41, 2.05)
Place of delivery				
Home delivery		1		1
Institution delivery		14.56(9.91, 21.41)		**14.82(10.07, 21.79)**
Wealth index				
Poor		1		1
Middle		1.17(0.75, 1.82)		1.18(0.75, 1.84)
Rich		0.86(0.55, 1.35)		0.84(0.53, 1.33)
Timing of first ANC visit				
Within the first Trimester		1.17(1.07, 2.04)		1.42(1.02, 1.96)
Second trimester and above		1		1
Media exposure				
No		1		1
Yes		2.84(1.96, 4.13)		**2.9(1.99, 4.23)**
Number of ANC visit				
One- two		1		
Three		1.18(1.03, 3.79)		**1.21(0.02, 3.87)**
Four and above		2.49(1.71, 6.15)		**2.02(1.86, 3.88)**
Community level factors				

Residence				
Urban			1.86(0.95, 3.62)	0.88(0.42, 1.83)
Rural			1	1
Region				
Tigray			4.27(1.24, 14.75)	2.03(0.45, 9.16)
Afar			1	1
Amhara			2.52(0.82, 7.78)	1.35(0.33, 5.49)
Oromia			0.83(0.26, 2.59)	0.44(0.11, 1.79)
Somali			0.37(0.11, 1.26)	0.68(0.13, 3.55)
Benshangul Gumuz			1.98(0.44, 8.99)	0.92(0.14, 5.95)
SNNPR			0.63(0.198, 2.01)	0.36(0.09, 1.52)
Gambella			2.18(0.29, 16.49)	1.52(0.13, 17.56)
Harari			1.40(0.14, 14.10)	0.77(0.04, 13.48)
Addis Ababa			7.55(1.66, 19.93)	4.39(0.89, 11.92)
Dire-Dawa			1.09(0.18, 6.58)	0.51(0.06, 4.19)
Community poverty level				
Low			1	
High			1.73(1.31, 2.28)	1.06(0.55, 2.06)
Community level education				
Low			1	1
High			0.75(0.43, 1.33)	1.24(0.88, 3.11)
Community-level media exposure				
Low			1	1
High			1.45(0.25, 3.82)	1.89(1.46, 4.77)
Random Effect Model				
Parameters	Null model	Model 1	Model 2	Model 3
Coefficient variance	0.4599	0.3367	0.3248	0.2913
Log-likelihood	-1200.50	-729.630	-1140.622	-712.697
Likelihood ratio		M1&m2= -941.74	M2&m3= 821.98	M3&m4= 855.85
Deviance	2401	1459.26	2281.24	1425.38
MOR	1.909	1.739	1.722	1.673
PCV	Ref	0.453	0.412	0.552
ICC	0.46	0.34	0.33	0.29

Table 4: Multi-level Analysis Factors Associated with Postnatal Newborn Care in Ethiopia, 2016MEDHS

3.8. Factors Affecting the Spatial Variation of Postnatal Newborn Care Delivery (Modeling Spatial Relationships)

3.8.1. Ordinary Least Square Regression

As shown in (Table 5) the OLS model described 63.2% (Adjusted $R^2 = 0.632$) of the variation in postnatal newborn care. Furthermore, all requirements of the OLS method were satisfied. The coefficients signify the strength and the type of each explanatory variable and the postnatal newborn care. Since the Koenker (BP) statistic was significant, we trust or consider the robust probability to determine the statistical significance of the coefficients. In addition, the Joint Wald statistic was statistically significant ($p < 0.01$) and this revealed the overall model was significant. Table 5 also revealed there is no Multicollinearity between explanatory variables with the variance inflation factor (VIF) < 7.5). In addition, the Jarque-Bera statistic was non-significant ($p = 0.104$) indicating the model residuals were normally distributed after rejecting the null hypothesis stating the residuals are normally distributed. (Table 5). Additionally, the Spatial Autocorrelation test (Moran's I = 0.08, P < 0.01) indicated that residuals were spatially auto-correlated.

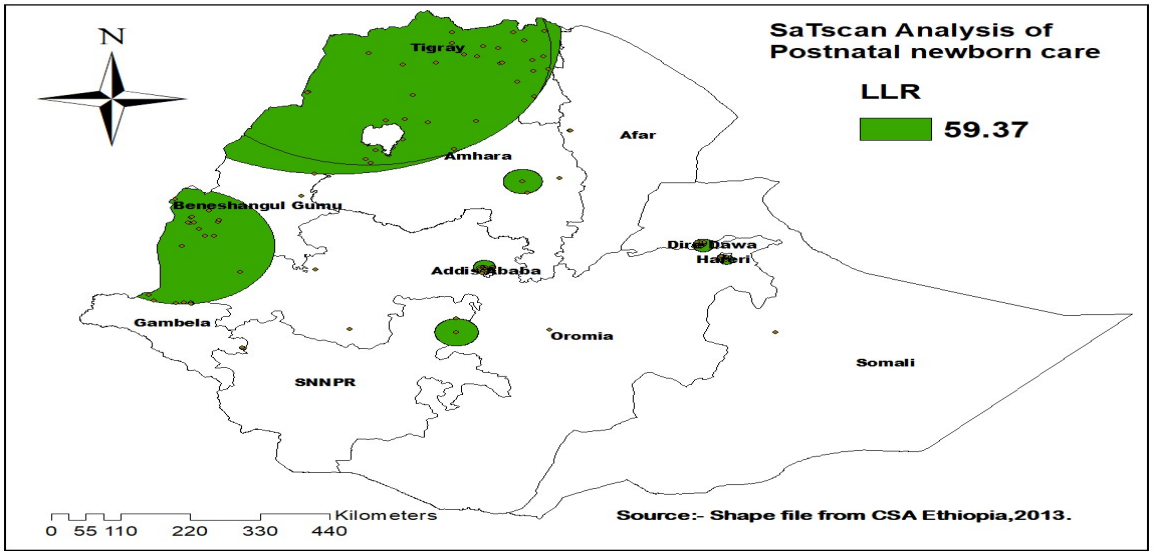

Figure 6: R Square for Showing Model Performance for Predicting Postnatal Newborn Care in Ethiopia, Map Produced Using Arcgis Version 10.7

3.9. Geographically Weighted Regression (GWR)

OLS model is a global model that assumes the relationship between each predictor variable and postnatal newborn care is stationary across the study area. As a result, the aim of fitting OLS regression is only to identify the predictors of PNNCs, and it is considered a model diagnostic test. After all, we conducted GWR to improve the model in case of non-stationarity between predictors and PNNCs. As shown in Table 6, the greater the adjusted R square, the lower Akaike's Information Criterion (AICc) value got from the GWR model (as compared to the OLS or global model) tells us to move from a global model (OLS) to a local regression model (GWR). That indicates conducting the GWR going to improve the model than the OLS (Tables 5 and 6). Figure 6, revealed the model performance (local R square) in which it was well performed/explained in central Somali, Oromia, the border between Dire-Dawa and Harari, between the border of Oromia and SNNPRs, regions (Fig. 6). Figures 7, 8, 9, and 10 showed that the geographical areas where the explanatory variables were strong and weak predictors of PNNCs in Ethiopia as well. Being mothers with gave birth in health facilities had a positive relationship with PNNCs. The green-colored clustered points (found in Gambella, SNNPR, North West Addis Ababa, and Southwest Benshangul) indicate areas where the coefficients were largest, which in turn indicate the strong positive relationship between delivery at health facilities and PNN Cs (Fig. 7).

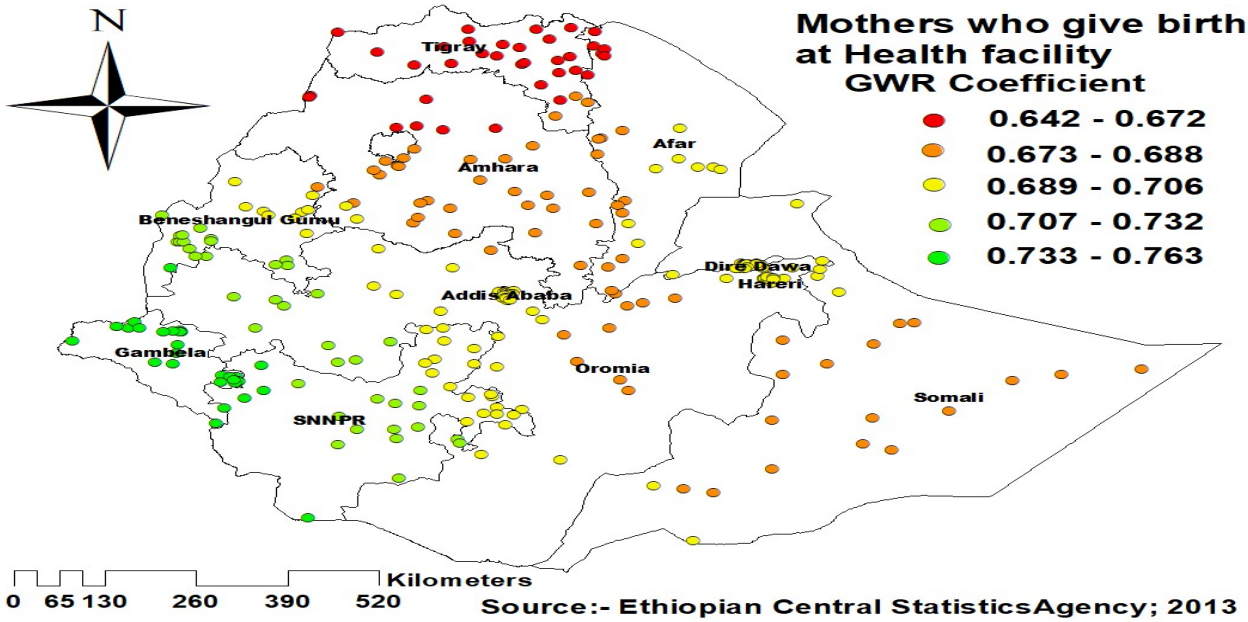

Figure 7: mothers give birth at a health facility in Ethiopia, Map produced using ArcGIS version 10.7

As shown in (Fig 8) Mothers Who had Media exposure showed a positive relationship with PNNCs in Somali, Harari, some Oromia, and Dire-Dawa have PNNCs (Fig. 8). As shown in Fig. 9, mothers with timing of her first ANC visit within the first Trimester had a positive relationship with PNNCs in SNNRP, Oromia, some parts of Addis Ababa and Somali regions (Fig. 9).

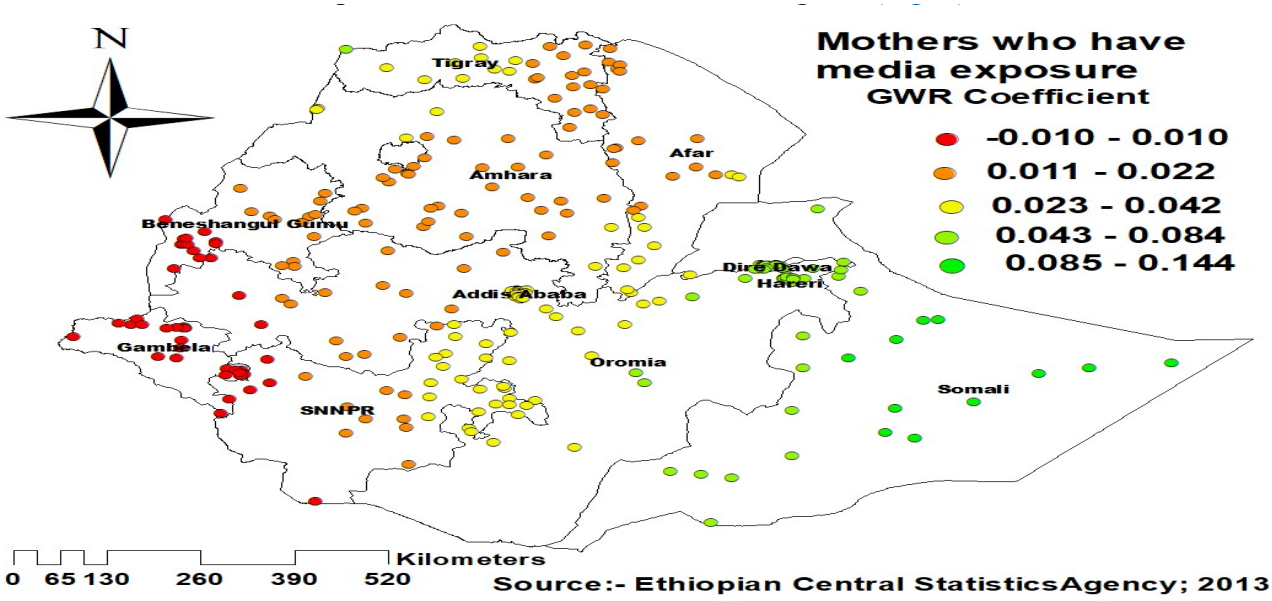

Figure 8: Mothers Who Have Media Exposure in Ethiopia, Map Produced Using Arcgis Version 10.7

Moreover, mothers with currently married (being married marital status) had a strong and negative relationship with PNNCs in Somali, Oromia, Harari, Dire-Dawa, and SNNRP regions (Fig. 10), which indicate areas where the coefficients were largest, which in turn indicates the strong negative relationship between Married marital status and postnatal newborn care.

Variables	coefficient	Standard error	t-statistics	probability	Robust standard error	Robust statistics	Robust probability	VIF
Intercept	0.364	0.09	3.94	<0.001	0.082	4.41	<0.001	----
Women who are Married	-0.256	0.095	-2.73	0.0067	0.081	-3.22	0.0014	1.02
Women who give birth in Health facility	0.71	0.042	16.84	<0.001	0.040	17.70	<0.001	1.74
Women who reside in Urban	-0.008	0.037	-0.22	0.83	0.04	-0.203	0.84	2.04
who check their first ANC visit within the First Trimester	0.003	0.04	0.07	0.94	0.045	0.065	0.95	1.23
Women who have media exposure	0.03	0.05	0.54	0.04	0.06	0.48	0.032	2.38
OLS Diagnostics								
Number of observations	305	Akaike's Information Criterion (AIC)					-87.66	
Multiple R-Square	0.638	Adjusted R-Squared					0.632	
Joint F-statistics	105.59	Prob(>F), (5299) degrees of freedom					<0.001	
Joint wald statistics	768.93	Prob(>chi-squared), (5) degrees of freedom					<0.001	
Koenker (BP) statistics	6.06	Prob(>chi-squared), (5) degrees of freedom					0.003	
Jarque-Bera Statistics	142.78	Prob(>chi-squared), (2) degrees of freedom					0.021	

Table 5: Summary of OLS results & diagnostics for postnatal newborn care in Ethiopia, MEDHS 2019.

Explanatory variables	Women who have married, who reside in an urban residence, women who have media exposure, who check their first ANC visit within the first Trimester, and women who give birth at a health facility.
Residual squares	11.53
Effective number	20.97
Sigma	0.201
Akaike's-Information Criterion (AICc)	-98.85
Multiple R-Squared	0.67
Adjusted R-Squared	0.65

Table 6: Geographically Weighted Regression (GWR) Model for Postnatal Newborn Care in Ethiopia, MEDHS 2019

4. Discussion

Postnatal newborn care (PNC) appears to be a crucial component of maternal and child care services and Newborn care is one of the main areas to achieve the sustainable development goal related to neonatal health [18]. However, evidence is inadequate about the spatial discrepancy of newborn care practice and there is insufficient evidence over the entire region of interest to adequately account for local spatial variations in Ethiopia. Therefore, the current study can be an input to show the spatial distribution as well as geographic variation of postnatal newborn care check-ups for further intervention and possible solutions by the concerned groups. In this study, the prevalence of postnatal newborn care is 39.6%, within two (2) days after birth. This finding is lower than that of a study conducted in Nepal at (58.6%) India at(40%), Tanzania at (64%) and studies done in Ethiopia [8,10,11,19,20]. This discrepancy might be due to the study time, nature of data, study population, the difference in methods used and study settings, socio-demographic characteristics of the study participants, and sample size variation. Furthermore, sociocultural practice and community lifestyle variation across the countries during the postnatal period can be the possible reasons. On the other hand, the prevalence of immediate postnatal newborn care practice in the current study is higher than the study conducted in Midwest Uganda which is (11%), and Kenya at (21.8%) [21,22]. The possible Reason might be due to the difference in outcome ascertainment. Because of the previous pieces of evidence newborn care practice was considered when all of the components were fulfilled whereas the current study measures the outcome variable when at least two components were fulfilled and this might make a higher prevalence compared to the previous studies as well.

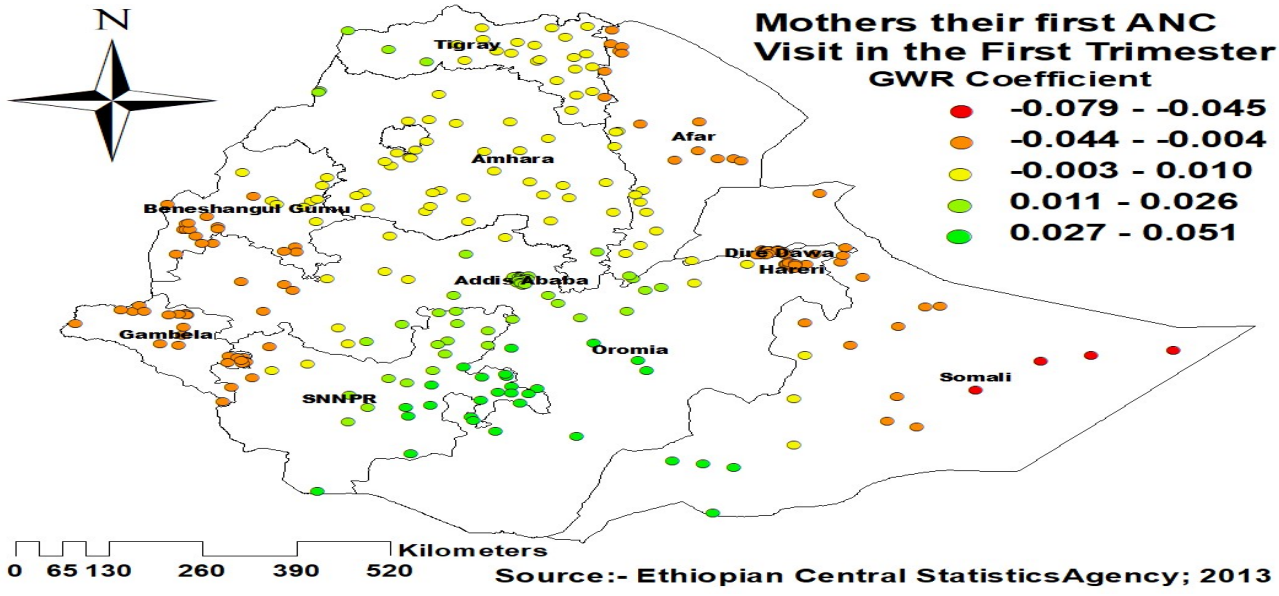

Figure 9: Timing of Anc Visits Within the First Trimester in Ethiopia, Map Produced Using Arcgis Version 10.7

From the spatial pattern, postnatal newborn care is not random and among the distribution, there is variation across regions of Ethiopia. Among all regions of Ethiopia Tigray, Amhara, and some of the Benishangul Gumuze, were characterized by high postnatal newborn care practices. The spatial scan statistics detected a total of 129 statistically significant primary clusters with a high prevalence of postnatal newborn care. Significant hotspot areas of postnatal newborn care (primary clusters) were observed in the eastern Tigray, Northern Amhara, Benishangul gumuz, border of SNNPR and southwestern Oromia region, a small proportion of Addis Ababa and the border of Dire-Dawa and Harari. other studies conducted in developing countries including Ethiopia also pointed

out the significant regional variations in the practice of postnatal newborn care [7,10]. This might be due to inaccessible health facilities and disparities in the distribution of limited resources like skilled and experienced health professionals to remote/ border areas of Ethiopia. In addition, this might be because of the sociocultural and socioeconomic differences between women in different regions as well as mothers from border areas who might have limited access to information regarding maternal and newborn health services and other services like access to school or health education. Women who give birth at health institutions are 14.82 times more likely to practice newborn care for their baby as compared to those women with give birth at home. The result is in line with the study conducted in some regions in Africa including Ethiopia [4,10,23–25]. The possibilities might be due to the possible explanation could be that health facility delivery enhances safe opportunities to access skilled maternity care providers and their newborns have a chance to access essential newborn care as well.

In contrast, women who give birth at home are part of unsafe and more traditional practices and are consequently less likely to access PNC services as a result [25].

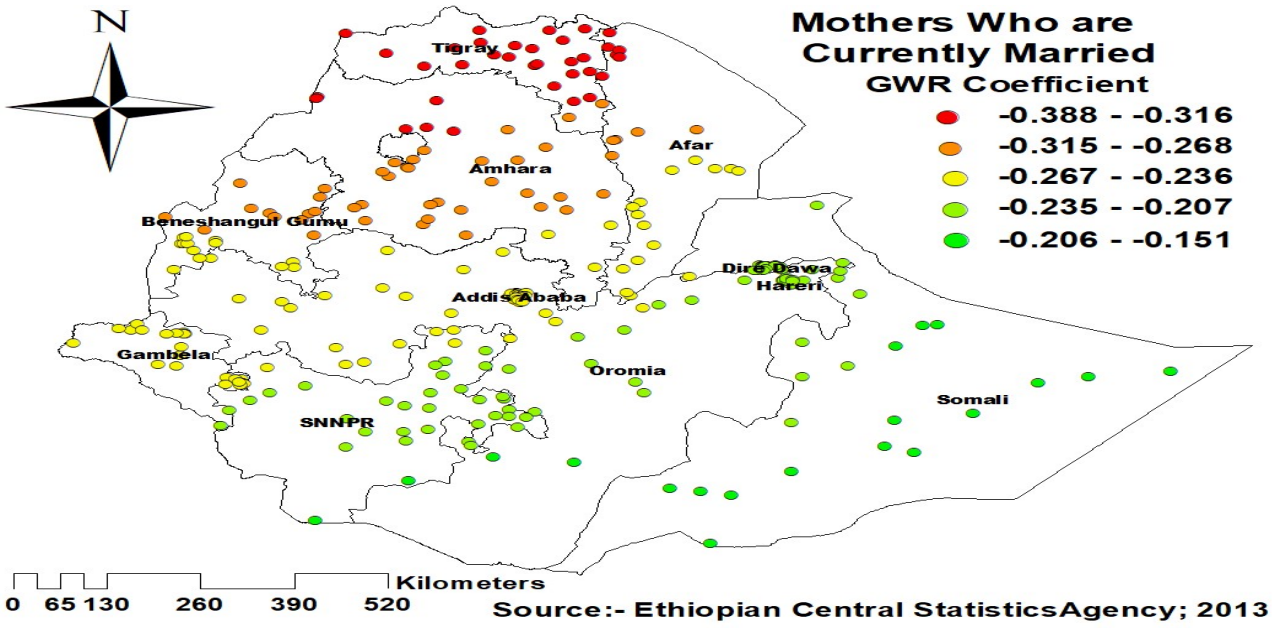

Figure 10: Women who are Married Marital Status, in Ethiopia Map Produced Using ArcGIS Version 10.7

Women from the community with good media exposure are 1.89 times more likely to have good postnatal newborn care practice compared with their counterparts. this finding is also in agreement with studies conducted in different parts of Ethiopia This might be due to the fact that those mothers who have access to media have been found to have good awareness about antenatal care visits and services, which enables them to know the benefits of postnatal care after birth for their newborn [4,7].

The number of ANC visits is a central determinant of Postnatal newborn care practice. This evidence coincides with that of previous studies elsewhere [7,8,14,20,24–28]. One probable explanation is that ANC provides a chance to understand the benefits of attending and the risks of not attending it, this awareness enables the mother to practice PNC for her and her newborn as well. As a result, women Who utilization of ANC per the schedule especially four and above visits were familiar with the follow-up and had appropriate counseling as well as advanced knowledge of the advantages of PNC during the ANC session. Furthermore, women may formulate and arrange their birth plans in collaboration with their ANC service provider, which might strengthen the utilization of hospital delivery and postnatal care services as well [27,29].

5. Conclusion

The national-level prevalence of postnatal newborn care is low. Place of delivery at health institution, timing of first ANC visits within the first trimester, married marital status, media exposure, and number of ANC visits four and above are positively associated with postnatal newborn care practices in Ethiopia. As a result, healthcare providers better to use ANC visits as a tool to advise and provide health information about the benefits and practice of PNC and encourage delivery at a health facility as well. Policymakers and Program managers about maternal and newborn health-related issues can take this finding as input to act on (intervene) in the identified areas of cold spot areas in newborn care practice in Ethiopia.

Strengths and Limitations of the Study

The use of weighted nationally representative data with a large sample is the central strength of the study, which makes it provide representative evidence at national and regional levels. Furthermore, the application of a multilevel model by considering

the hierarchical nature of the MEDHS data can control the variability within the community to get a consistent estimate and standard errors. But it has its drawbacks/limitations mainly resulting from the use of secondary data. some important confounders like the health service quality, current pregnancy wanted, occupational status, and behavioral factors are lost. The other limitation of this study is taking into account women's postpartum period two years before the survey might introduce recall bias.

Data Availability Statement

The original contributions presented in the study are included in the article/ further inquiries can be directed to the corresponding author.

Ethical Statement

The study does not obtain direct collection of data/information from individuals and does not use single secondary records. As a result, Informed Consent to participate and any single waiver is not applicable. We submitted a one-page proposal abstract about the study to the DHS program office. The office offers permission to access the data with reference number 182567 as well.

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Competing interests

There are no competing interests.

Author Contributions

The conception of the research idea, study design of the work, acquisition of data, formal analysis, and interpretation of data, Writing – original draft, Writing – review & editing: were done by GSA, FMA, TMT, AHT, TKT, WSS, TYB, YMC, WSJ, NBG. Data curation, investigation, resource, supervision, validation, visualization, and submission by GSA.

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