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Spatial Patterns and Determinants of Postnatal Care Use in Ethiopia: A finding from Demographic and Health Survey, 2016

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Manuscripts



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2 **Spatial Patterns and Determinants of Postnatal Care Use in Ethiopian: A finding from**
3 **Demographic and Health Survey, 2016**
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Abstract

Objective: In Ethiopia, postnatal cares (PNC) is one of the components of care to be provided to mothers and child. This study was aimed to explore geographical variations and identify the determinants of PNC utilization among women after delivery in Ethiopia.

Methods: Ethiopian Demographic and Health Survey 2016 data were used and 7,193 women between 15-49 years of age were included in the analysis. The proportion and patterns of women who receive a health checkup after discharge and home delivery were explored across the country. A multilevel logistic regression model was used to identify predictors of PNC utilization. Odds ratio with 95% confidence intervals were calculated to determine statistical significance. Mapping and spatial analysis were done using ArcGIS v10.1 while all other data processing and analysis were done in Stata 14.

Results: The proportion of PNC utilization was 6.9 % (95% CI: 6.3%, 7.5%). Spatial variations were observed. Dire Dawa, Harari, and Jigjiga were with low utilization, whereas Tigray region utilized PNC highly at 99% confidence level. Factors including, mother with no education (AOR=0.55, 95%CI: 0.37, 0.84) and poorest wealth status (AOR=0.55, 95% CI: 0.39, 0.78) consistently predicted the lack of usage of PNC. In contrast, mothers in 35 – 49 years (AOR: 1.75, 95%CI: 1.01, 3.04) and women with at least one ANC visit (OR=2.37, 95% CI: 1.71, 3.29) were more likely to use PNC.

Conclusion: Postnatal care utilization remains public health problem and has spatial variations at the regional level of the country. Uneducated women, young age, and poverty are barriers to PNC utilization. Educational status, wealth status, the age of mothers and ANC visits were predictors for PNC utilization. Hence, health promotion on ANC utilization and other predictors would be supreme important for better utilization of PNC.

Keywords: Postnatal Care, Primary Care, Public Health, Demography, and Health Survey, Maternal Medicine

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Strengths and limitations of this study

- The study used a national large-scale data and applied advanced approach.
- It is potential for cross-country comparison and interventions.
- The analysis was designed to identify predictors of PNC and spatial patterns, but it does not point directly to explanations for these outcomes. This is a less helpful for explaining causality.
- The study has presented the experiences of the participants in the 5 years that followed the study period. This might lead to recall biases, which in turn the findings may not be generalizable.
- There may be unmeasured variables that predict the outcomes. One example is health facility-related factors like quality of services. Further research should consider the potentially important predictors.

Background

In 2015, roughly 66% of the world's maternal mortality was found in Sub-Saharan Africa [1, 2]. A report in Ethiopia showed the presence of a large proportion of maternal and neonatal deaths despite the health system focusing on improving maternal health [3].

PNC is used as an indicator of maternal health care in the post-partum period [4]. The World Health Organization (WHO) and Federal Ministry of Health (FMOH) of Ethiopia recommended that mothers must receive postnatal care at least once during the post-partum period [5-7]. Ethiopian health policies focus on maternal and child health care. As a result, maternal mortality rate decreased from 897 to 412 per 100,000 between 2000 and 2016 [6], while the antenatal care (ANC) is increased from 10.4% to 32% [8, 9]. However, PNC utilization remains very low in which only 13 to 26% of women received PNC in the last five years [10].

Studies done in developing countries have looked into the factors associated with postnatal care utilization. Mother's Socio-demographic characteristics, including household wealth status, maternal education, maternal occupation, and residence were positively associated with PNC [11,12]. In addition, history of ANC, place of delivery and mother's knowledge of postpartum danger signs and symptoms are important predictors of postnatal care service utilization[13]. On the other hand, PNC service utilization depends on birth-related complication that can end maternal and neonatal death [14-16].

The Ethiopian Ministry of Health has developed strategies to improve maternal and child health care utilization which is free of charge [17]. However, it is noted that the magnitude of maternal

1 health services is heterogeneous geographically. Additionally, the extent of key barriers to PNC
2 utilization is unexplored, which are cause maternal and neonatal death during the postnatal
3 period. In Ethiopia, characterizing the spatial distribution of PNC utilization is essential to
4 prioritize risk areas to interventions. In another word, Understanding the levels and
5 geographical variations of PNC utilization would help policymakers, planners, programmers and
6 partners in the health sector to formulate appropriate strategies and interventions and provide
7 quality reproductive health services. Therefore, this study was aimed to explore geographical
8 variations and identify the determinants of PNC utilization among women after delivery in
9 Ethiopia.

17 **Methods**

19 **Study setting**

21 The study was conducted in Ethiopia, the country composed of nine Regional State and two city
22 administrations. The country is the second most populous country in sub-Saharan Africa, with a
23 population of over 100 million people and is a mainly rural country with only 17% of the
24 population living in urban areas [18, 19]. Ethiopia has improvement in the coverage and
25 utilization of the healthcare service after implementation of Health Sector Development Plan
26 (HSDP) through decentralized in three-tier structure. Mainly, health centers provide
27 preventative and basic curative services with referral system to the nearest high level of care
28 [17]. Primary health cares are offered to all women free of charge including PNC in the country.
29 In addition, the health centers composed a number of staffs such as health extension workers
30 and health development army (HDA) to improve Universal Primary Health Care (PHC)
31 coverage at the lowest level of administration.

40 **Study design**

42 We used Ethiopian Demography and Health Survey (EDHS) 2016 data which was a national
43 representative cross-sectional survey [20].

46 **Study Population**

47 The 2016 EDHS is the fourth Demographic and Health Survey conducted in the country. The
48 study population was any women in childbearing age who gave birth in the last five years
49 residing in the randomly selected enumeration areas (EAs). The study subjects were any
50 women in childbearing age that gave birth in the last five years in Ethiopia.

1 **Sampling technique and Sample size**

2 The EDHS 2016 used a stratified two-stage cluster sampling design. The EAs were the primary
3 sampling units and households were the second stage-sampling units. The survey included
4 15,683 women between ages 15 to 49 years old. A total of 7,193 women gave at least one birth
5 in the last five years preceding the survey were included in the final analysis of this study.
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10 **Data source and extraction**

11 In Ethiopia, every five years, the Demographic and Health Survey program has collected data
12 on national representative samples of all age group and key indicators including child health
13 and maternal-related variables. Data collection took place from January 18, 2016, to June 27,
14 2016. EDHS datasets are available in the Measure DHS program website. After reviewing, we
15 extracted 7,193 women data. The national shapefiles were used to maps the variations using
16 ArcGIS 10.1.
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22 **Variables of the Study**

23 The outcome variable of this study was women's health checkup after discharge or delivery at
24 home (PNC utilization). Based on WHO guideline, PNC utilization defined as women who
25 received any postpartum check after discharge from a health facility or delivery at home and
26 extends up to six weeks (42 days) after birth prior to a survey [7, 21]. The response was
27 dichotomized as "1" if the woman received at least one health checkup after discharge or
28 delivery at home, otherwise assigned "0".
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34 Independent variables were sociodemographic variables (age, educational level, occupation,
35 religion, residence, region, and household wealth quintile), maternal reproductive health-related
36 factors (place of delivery, antenatal care visit, sex of the child and health professions who
37 checked maternal health after discharge or delivery at home.
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42 **Data processing and analysis**

43 After survey data extraction, further coding and analysis were done using STATA version 14
44 software. Sample weights were used to avoid geographical strata selection variability as well as
45 for non-responses. The detailed explanation of the weighting procedure elsewhere in EDHS
46 final report [22].
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50 Descriptive measures were used to summarize the overall characteristics of the study
51 participants in the study area.
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53 **Spatial Data analysis**

54 The spatial patterns of PNC were analyzed using Geographical Information System (ArcGIS
55 version 10.1) software. The application of GIS with spatial statistics clearly exhibited the spatial
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2 pattern of PNC. Spatial Autocorrelation analysis was performed to test whether the cases were
3 distributed randomly over space and identified the pattern of PNC was clustered, dispersed, or
4 random. Moran's I calculated I values as $I=0$ values was for random distribution, $I<0$ values for
5 dispersed, and $I>0$ values for clustered [23].
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9 The cluster-outlier analysis (Anselin Local Moran's I) was employed to distinguish between a
10 statistically significant ($p<0.01$) cluster of high values (High-High), cluster of low values (Low-
11 Low), outlier in which a high value is surrounded primarily by low values (High-Low) and outlier
12 in which a low value is surrounded primarily by high values (Low-High) [24]. A positive value for
13 'I' indicated that features with similar values, such type of feature surrounded the feature was
14 part of a cluster. A negative value for 'I' indicated that features with dissimilar values
15 surrounded the feature. Such a feature was an outlier [25].
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20 21 **Disease Cluster Detection and Spatial Scan Statistical Analysis**

22 We applied spatial scan statistical analysis using Kuldorff's SaTScan version 9.4 software [26],
23 to test for the presence of statistically significant spatial clusters of PNC. The spatial scan
24 statistic uses a scanning window that moves across space [24]. The spatial patterns of PNC
25 and its statistical significance was tested by Bernoulli probability model. With the assumption of
26 Bernoulli probability function, we tested the null hypothesis whether there was no difference
27 within the spatial window and outside the window. The default maximum spatial cluster size of
28 $<50\%$ of the population was used, as an upper limit, which allowed both small and large
29 clusters to be detected and ignored clusters that contained more than the maximum limit. For
30 each potential cluster, a likelihood ratio test statistic was used to determine if the number of
31 observed cases within the potential cluster was significantly higher than expected or not. The
32 circle with the maximum likelihood ratio test statistic was defined as the most likely (primary)
33 cluster. The maximum observed value of the test statistic for each potential cluster was then
34 compared with the overall distribution of maximum values. The primary and secondary clusters
35 were identified and assigned p-values and ranked based on their likelihood ratio test, on the
36 basis of 999 Monte Carlo replications [27, 28].
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48 **Statistics Analysis**

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50 Multilevel binary logistic regression was used to calculate the measures between each of the
51 independent variables (mother and household characteristics) and the likelihood of mothers
52 using PNC services. The rationales for using a multilevel modeling were due to the multistage
53 cluster sampling procedure, individual women were nested within clusters. Hence, the likelihood
54 of women seeking maternal health services is likely to be correlated to the cluster members.
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Variables that had a relationship with PNC utilization ($p < 0.25$) were considered for the final model. Odds ratios with 95 % CI were used to declare statistical significance.

Results

Socio-Demographic characteristics of the study subjects

A total of 7,193 women age 15-49 years who had at least one birth in the five years before the study period were included in the analysis. The majority 6621 (87.2%) of the respondents were rural residents. The mean age of the respondents was 29.26 years (SD \pm 6.9). About 4791(63.1%) of the respondents had no education and about one-third of the respondents were in the poorest wealth quintile. The majority of the participants were from Oromia Regional State 3130 (41.2%) followed by 1633 (21.5 %) Amhara Regional State and SNNP 1601(21.1%).

Postnatal Care coverage

The proportion of postnatal health checkup after discharge or home delivery was found to be 6.9% (95% CI: 6.3%, 7.5%), with urban, 10.6% (95% CI: 9.1, 12.2), and rural 5.9% (95% CI: 5.3, 6.6)). PNC service utilization varied across the regions of the country with the highest proportion (15%) in Tigray regional state and lowest proportion (3%) in Gambella and Somali Regional State. The proportion of women's health checkup after discharge or delivery at home in the women having antenatal care at least four visits was 10.5 % and, in the women, who delivered at a health facility was 9.1 % (**Table 1**).

Spatial distribution of PNC Utilization

The global Moran's index statistic was 0.084 (p -value < 0.0001), indicating the presence of a significant positive spatial autocorrelation in women's health checkup after discharge or delivery at home in Ethiopia (**Figure 1**). The spatial clustering is highly pronounced at a distance of 225.2 KMs with a corresponding Z score of 12.592741 (P -value < 0.0001). According to LISA analysis, high clusters were observed in the major part of Tigray region (Central, eastern, western and southern Tigray) at 99% confidence level, but at 95%CI it was found at Addis Ababa town, western Tigray, North Shewa, south Shewa and East Gojjam zone of Amhara regional state, Arsis zone of Oromia region and Gurage zone of SNNP region. In contrast, low significant clustering of women's health checkup after discharge or delivery at home were major parts of Gambella region, Harari, jijjig and Eastern Haragie.

Moreover, the SaTScan spatial analysis was identified three clusters. The primary clusters (LLR = 20.72, $p < 0.0001$) were detected in Southeastern Ethiopia. A second cluster (LLR = 19.36, $P < 0.0001$) were detected in east of Ethiopia. The final cluster (LLR = 10.91, $P = 0.048$), were in Northern Ethiopia (**Table 2, Figure 2**).

Despite all observations were low, relatively the highest percentage of women's health checkup after discharge or delivery at home was observed in Tigray region, 15.6% and Addis Ababa, 13.1%, whereas the lowest observation in Somali (3.0%), Oromia (3.6%) and Afar (4.2%) (**Figure 3**).

Factors associated with PNC utilization

Demographic and socio-economic variables were selected using Enter methods at 0.25 significance level. In the final model, maternal education, wealth index and ANC visit were identified as associated factors with women's health checkup after deliver.

Level of education showed strong statistical association with postnatal care service utilization. Mothers who have no education were about 33% times (AOR=0.55, 95%CL: 0.37, 0.84) less likely to utilize postnatal care service than educated (above Secondary) women. Similarly, the odds of poorest decreased the chance of utilizing postnatal care service by about one-third fold (AOR=0.55, 95% CI: 0.39, 0.78) less likely than richest women.

Age of women has also been an important predictor of postnatal care service utilization. Mothers who age group in 35 – 49 years were about 1.75 times (AOR: 1.75, 95%CI: 1.01, 3.04) more likely to utilize postnatal care service utilization than younger than 19 years. Postnatal care service utilization also increased with increasing ANC visits of mothers. Women who had one to three ANC visit (OR=2.37, 95% CI: 1.71, 3.29) were more likely to receive health checkup after delivery than no Antenatal Care. Moreover, Mothers who had fourth ANC visit were about 3-fold (AOR: 3.43, 95%CI: **2.47, 4.76**) more likely to utilize postnatal care service than those who had no any type of ANC visits (**Table 3**).

Discussion

This study was investigated factors and spatial variations of postnatal care utilization among Ethiopian women using the 2016 Ethiopian DHS data.

The study showed that Ethiopia continued to have a low proportion of postnatal care utilization. The finding was smaller than 2011 EDHS [8, 12] that indicated maternal and child health

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2 remains poor. This may be attributed to the samples difference and could be an improvement in
3 the quality of data to date. It was found to below with studies done in Amhara region, Ethiopia
4 [14, 29] and southern Ethiopia [30]. The difference might be due to our study include rural areas
5 and study characteristics. This low result may be attributed by Programmatic problem impact on
6 a woman's making a PNC visit and low exposure to the mass media. In comparison with other
7 countries, Ethiopia is behind in postnatal care utilization; including Kenya (47%)[31, 32], Nigeria
8 (29%) [33], Nepal (40.9%) [11] and Tanzania (10.5%) [34]. This variation can also be attributed
9 due to the time difference and could be an improvement in health care utilization conducted in
10 Kenya unlike to our study. The postnatal care utilization is varied geographically in Ethiopia.
11 Specifically, Tigray region and Addis Ababa city have hotspot areas. The study found that PNC
12 was considerably varied in demographic characteristics; for example, 57% women who
13 delivered at a health facility, Orthodox religion (12.9%) and Addis Ababa residents (51.6%)
14 were more user and PNC utilization was directly increased as the level of maternal education
15 and wealth index. This Study consistent studies conducted in Ghana and India found some
16 geographic variations in socioeconomic inequalities [35, 36].

17
18 This study identified several factors that indicate a strong influence on the utilization of PNC
19 services: age of mother, mother's level of education, household wealth quintile and ANC visit.
20 Those women with no education less likely to use postnatal care as compared to women who
21 educated more than secondary school. This finding is consistent with Nigeria [37], Kenya [32]
22 and Nepal [11], Ethiopia[12, 14, 30, 38, 39] and India [36]. This could be explained by the fact
23 that education has a valuable input in enhancing female autonomy and help women develop
24 greater confidence and capability to make decisions about their own health. Thus, literate
25 women seek out higher quality health services and have greater ability to use health care inputs
26 that offer better health outcomes.

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28 Similarly, Women in poorest wealth quintile level were less likely to use PNC as compared to
29 richest wealth quintile in attending at least one postnatal care visit. This study is similar to
30 evidence from a study conducted in Ethiopia [12]. Our finding is also in line with others studies:
31 Pakistan [40], Nepal and Rwanda[11, 41]. Richest Women's may get more information about
32 Children's Health from mass media and health professionals privately subsequently; families
33 may arrange institutional health services.

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35 Postnatal care utilization was positively associated with antenatal care service. That is Mothers
36 who attended ANC services more frequently were more likely to receive PNC services

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2 compared to those who had attended less than one ANC services. This finding is similar to
3 study in Nepal[11], India[36]Tanzania [34] and Kenya [32]. The possible reason may be ANC
4 users perceived that health system has provided quality care based on previous experiences.
5 Furthermore, this could be due to variations of socio-demographic, cultural differences, which
6 may lead to health service related to pregnancies.
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11 In this study, we found that mother's older age at delivery was positively associated with PNC
12 use. Our finding contrasts with a study done in Rwanda[41]. The main reason is differences in
13 culture. In Ethiopia, older women were more involved in their own health care decision-making
14 and respected than younger women. This may be reinforced that women who are empowered
15 to make health care choices previous experiences and then older women more likely to use
16 PNC services.
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22 The study has addressed PNC utilization and spatial disparity; however, it has the following
23 limitations. First, the analysis is designed to identify predictors of PNC and spatial patterns, but
24 it does not point directly to explanations for these outcomes. This is a less helpful for explaining
25 causality. Secondly, the study has represented the experiences of the participants in the 5
26 years that followed the study period. This might lead to recall biases, which in turn the findings
27 may not be generalizable. Finally, there may be unmeasured variables that predict the
28 outcomes. One example is health facility-related factors like quality of services. Further
29 research should consider the potentially important predictors.
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37 **Conclusion:** Postnatal care utilization among women in Ethiopia was low and varied across
38 socio-demographic characteristics. Regional disparity (Spatial pattern) was observed in
39 postnatal care utilization among Ethiopian women. Higher educational level, better wealth
40 index, antenatal care at least one visit and place of delivery were significant predictors of
41 postnatal care utilization among women in Ethiopia. Thus, there is a need to devise such
42 strategies, ensuring availability, accessibility and affordability of PNC for mother and newborn
43 considering the geographical difference. Emphasis should be given to designing public health
44 interventions to educate and raise awareness among mothers and families regarding the
45 importance of PNC, timing for PNC check-up.
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List of abbreviations

ANC	Antenatal Care
CI	Confidence Interval
CSA	Central Statistical Agency
DHS	Demographic and Health Survey
EA	Enumeration Area
EDHS	Ethiopia Demographic and Health Survey
FMOH	Federal Ministry of Health
OR	Odds Ratio
PNC	Post Natal Care
SD	Standard Deviation
SNNP	Southern Nations Nationalities and Peoples
SPSS	Statistical Software for Social Science
WHO	World Health Organization

Declarations

Ethics consents

Permission consent was obtained to access the 2016 Ethiopia Demographic and Health Survey from Measure DHS International Program, which authorized the data sets. All data were extracted without having any personal identifying information that could be linked to particular individuals, communities, or study participants. As the study was secondary data analysis, the research ethics was waived. Confidentiality of data maintained anonymously.

Consent for publication

Not applicable.

Availability of data and material

All relevant data are available within the manuscript. However, the minimal data underlying all the findings in the manuscript will be available upon request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

TT, YW, AT and DK conceptualized and designed the study. MM, MF, TT, YW, AT and DK carried out the literature review, data extraction and analysis. MM drafted the manuscript. KA, TA AA and MF participate in data analysis and reviewed the manuscript. All authors read and approved the final version of the manuscript.

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Table 1: Postnatal care use by background characteristics among women age 15-49 who had given birth in the five years preceding the survey, EDHS 2016

Background Characteristics		PNC Use (%)	Total number of women PNC Use	
			Weighted	Unweighted
Age (in Years)	15 - 19	4.4	338	358
	20 - 34	6.6	5291	5041
	35 - 49	5.8	1960	1794
Religion	Orthodox Christian	9.4	2882	2369
	Muslim	4.0	2824	3324
	Protestant	5.5	1652	1338
	Others*	0.9	232	162
Residence	Urban	12.1	969	1512
	Rural	5.5	6621	5681
Region	Tigray	15.6	538	772
	Afar	4.2	71	647
	Amhara	8.0	1633	764
	Oromia	3.6	3130	1031
	Somali	3.0	269	806
	Benishangul	7.4	81	576
	SNNPR	6.3	1601	893
	Gambella	4.8	21	534
	Harari	11.1	18	411
	Addis Ababa	13.6	198	375
	Dire Dawa	9.1	33	384
Maternal Education	No education	4.8	4791	4359
	Primary	7.7	2150	1942
	Secondary	11.9	420	577
	Higher	13.5	229	315
Husband/partner's education level	No education	4.9	3345	3136
	Primary	6.6	2731	2160
	Secondary	9.3	612	745
	Higher	10.9	376	569
	Don't know	9.3	43	52
Wealth index	Poorest	3.1	1652	2428
	Poorer	3.9	1654	1179
	Middle	5.9	1588	1028
	Richer	8.3	1426	917

	Richest	11.8	1269	1641
ANC Visit	No ANC Visit	2.4	2818	2481
	ANC one to three visits	6.6	2342	2092
	ANC at least four visits	10.5	2429	2620
Place of Delivery	Health facility	9.1	2408	2699
	Other than Health facility	5.0	5181	4494
Sex of child	Male	5.8	3941	3718
	Female	6.8	3649	3475
Child Wanted	Wanted then	5.9	5573	5741
	Wanted later	7.9	1321	991
	Wanted no more	6.0	695	461
Birth Order	1	7.1	1434	1470
	2 - 3	7.2	2281	2217
	4 - 5	6.0	1752	1638
	6+	5.0	2122	1868

*Catholic, Traditional and other unclassified

Table 2: Cold spot areas of SaTScan spatial analysis result of Women's health checkup after discharge or delivery at home in Ethiopia from EDHS 2016 data

Cluster	Zone	Coordinates/Radius	LLR*	P Value
1	Nuer and Agnuak administrative zones of Gambella region, Sheka, Majang, Keffa, Benchi Maji, Konta, Dawro, South Omo and Basketo Gamo goffa Administrative zones of SNNP region and Kelem Wollega, West Wolega, East Wollega, Kemash and Jimma administrative zones of Oromiya region	7.396504 N, 35.260203 E / 225.20 km	18.07	< 0.0001
2	Doolo, Korahe, jarar and Nogab administrative zones of Somali Region, Borena, Guji, Bale, West Arsi, West and East Hararge administrative zones of Oromiya region and Gedio & Sidama administrative zones of SNNP.	4.180558 N, 42.052871 E / 467.62 km	14.19	< 0.001
3	Bale and Guji administrative zones of Oromiya Region, Liben, Afder and Shabelle administrative Zones of Somali region	4.180558 N, 42.052871 E / 282.34 km	10.28	0.024

*Log Likelihood ratio

Table 3: Factors Associated with PNC utilization among Women giving birth in the 5 years preceding the survey who had their 1st postnatal checkup within the 1st 42 days after delivery in Ethiopia, EDHS 2016.

Variables	PNC use		COR (95% CI)	AOR (95% CI)	
	Yes	No			
Maternal Education	No Education	226	4,133	0.39(0.27, 0.56)	0.55(0.37, 0.84)
	Primary	158	1,784	0.57(0.39, 0.83)	0.69(0.46, 1.01)
	Secondary	67	510	0.81(0.54, 1.23)	0.87(0.57, 1.315)
	Above Secondary	45	270	1	1
Age (in Years)	15 - 19	16	342	1	1
	20 - 34	351	4,690	1.47(0.88, 2.47)	1.47(0.87, 2.48)
	35 - 49	129	1,665	1.46(0.85, 2.51)	1.75(1.01, 3.04)
Religion	Orthodox Christian	246	2,123	1	
	Muslim	179	3,145	0.83(0.63, 1.11)	
	Protestant	69	1,269	0.78(0.54, 1.14)	
	Others*	2	160	0.18(0.04, 0.75)	
Residence	Urban	160	1,352	1	
	Rural	336	5,345	0.60(0.47, 0.76)	
Wealth Index	Poorest	87	2,341	0.39(0.28, 0.547)	0.55(0.39, 0.78)
	Poorer	74	1,105	0.64(0.45, 0.89)	0.75(0.54, 1.056)
	Middle	75	953	0.77(0.55, 1.07)	0.85(0.61, 1.19)
	Richer	80	837	1.06(0.78, 1.45)	0.94(0.63, 1.407)
	Richest	180	1,461	1	1
ANC visit	No Antenatal Care	58	2,423	1	1
	ANC one to three visit	141	1,951	2.58(1.88, 3.54)	2.37(1.71, 3.29)
	ANC at four visits	297	2,323	4.09(3.01, 5.549)	3.43(2.47, 4.76)
Sex of child	Male	233	3,485	1	
	Female	263	3,212	1.20(1.00, 1.45)	
Place of Delivery	Health Facility	266	2,433	1	
	Otherthan Health Facility	230	4,264	0.67(0.54, 0.82)	

*Catholic, Traditional and other unclassified

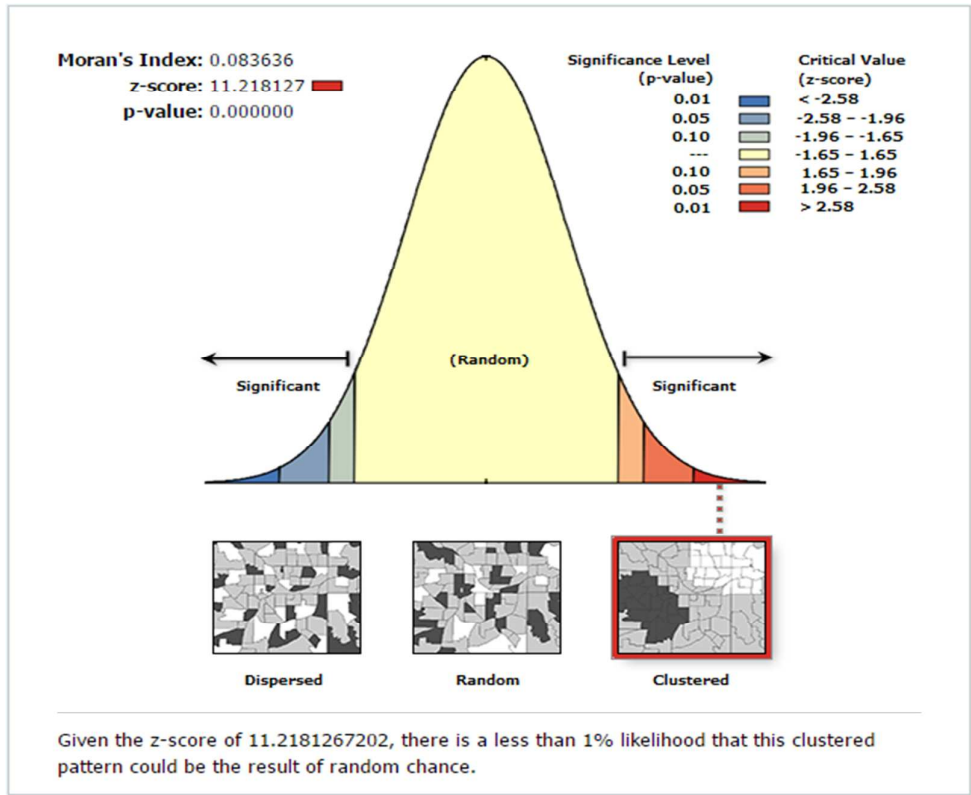
Figure legends

Figure 1: Spatial autocorrelation based on feature locations and attribute values using the Global Moran's I statistic.

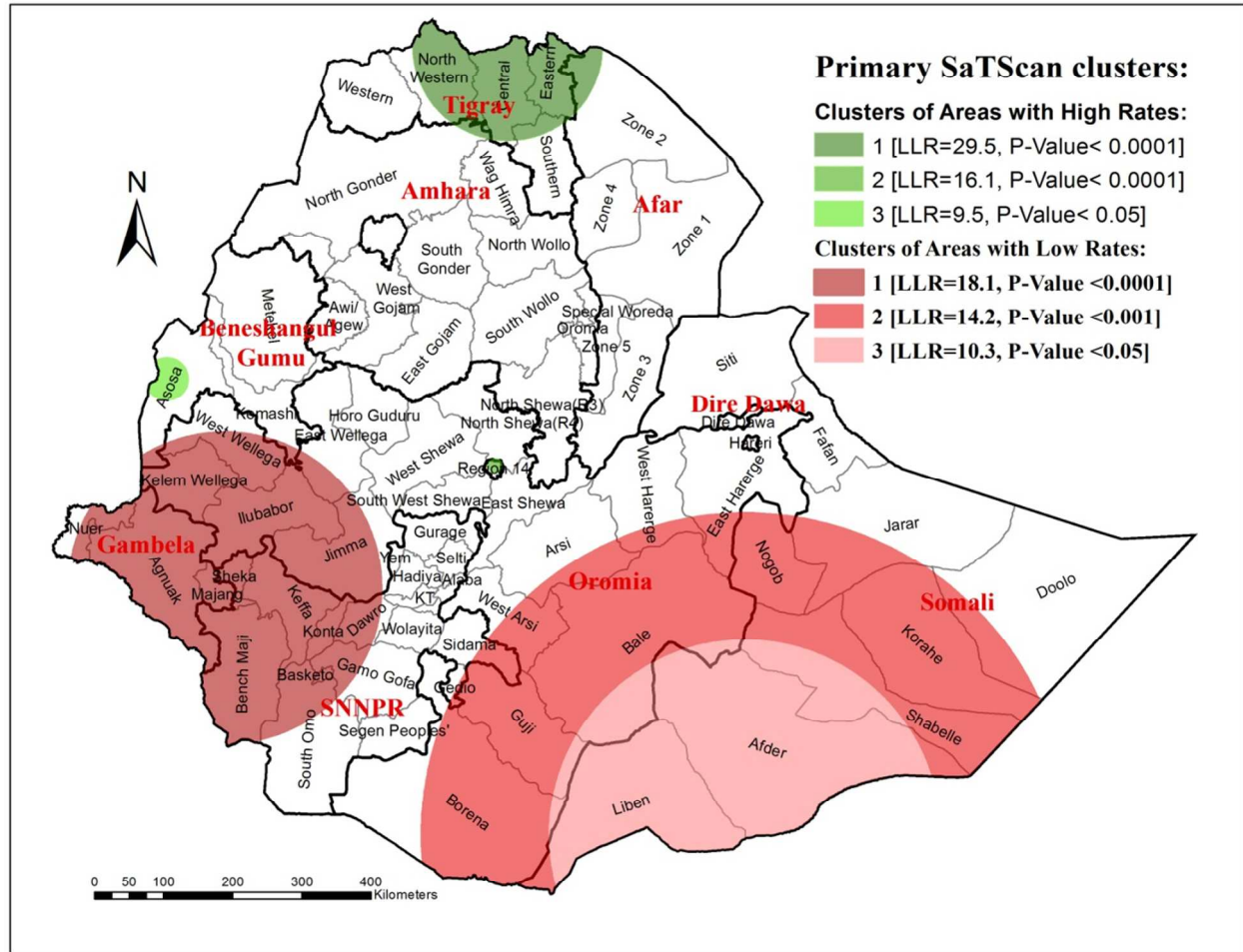
Figure 2: Spatial Clustering of Women's health checkup after discharge or delivery at home in Ethiopia, EDHS 2016

Figure 3: Spatial distribution of Women's health checkup after discharge or delivery by percentages, Ethiopia, EDHS 2016

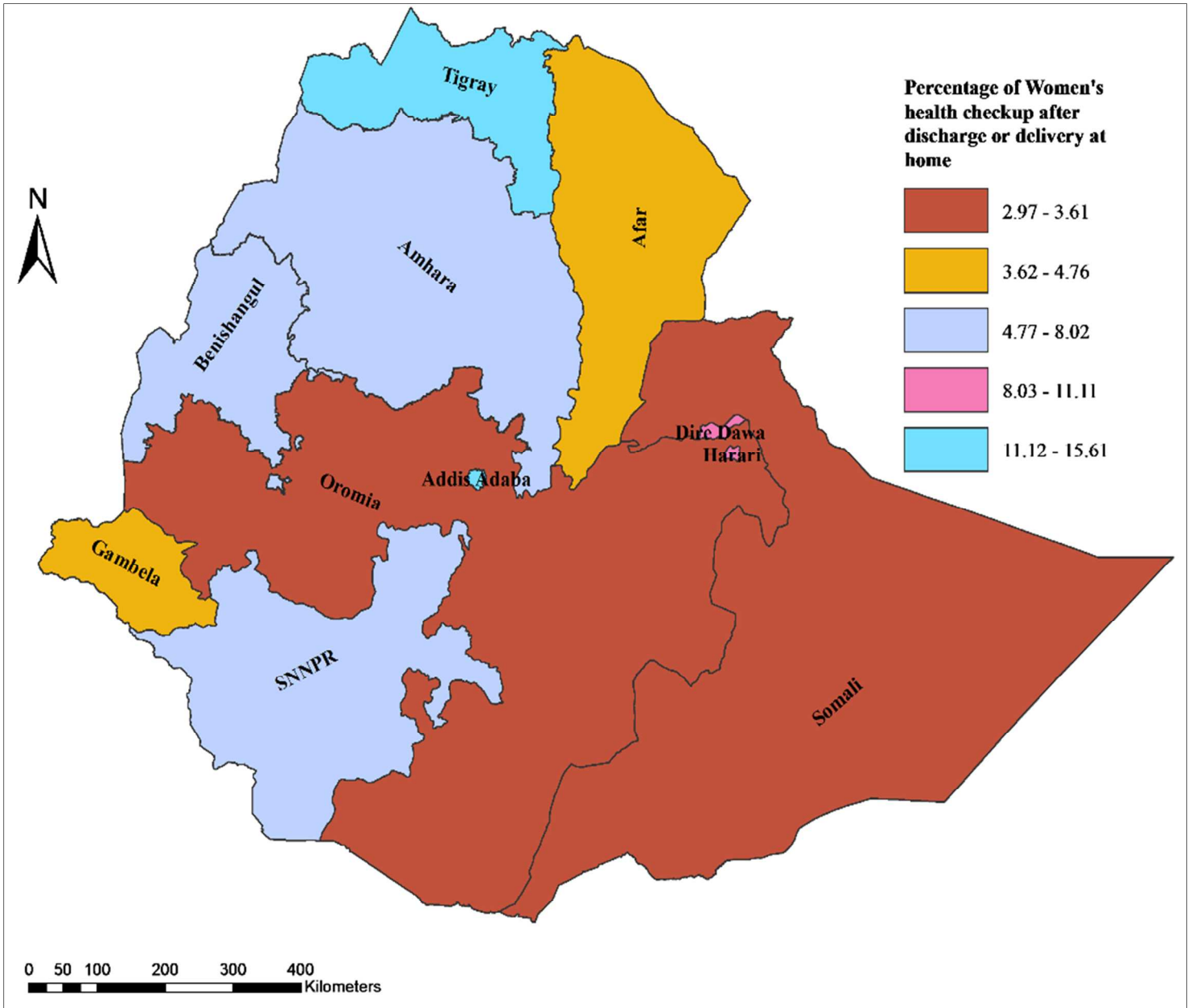
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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of cross-sectional studies

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	<p>Spatial Patterns and Determinants of Postnatal Care Use in Ethiopian: A finding from Demographic and Health Survey, 2016</p> <p>Objective: Postnatal cares (PNC) is one of the components of care to be provided to mothers and child. In Ethiopia, characterizing the spatial distribution of PNC utilization is essential to prioritize risk areas where PNC is needed and facilitate interventions. This study was aimed to explore geographical variations and identify the determinants of PNC utilization among women after delivery in Ethiopia.</p> <p>Methods: Ethiopian Demographic and Health Survey 2016 data were used and 7,193 women between 15 - 49 years of age were included in the analysis. The proportion of women who receive a health check-up after discharge and home delivery were recorded. Spatial cluster and autocorrelation analysis were done to explore the patterns of PNC utilization across the country. Multilevel logistic regression model was used to identify predictors of PNC utilization. Odds ratio with 95% confidence intervals (CI) were calculated to determine statistical significance. Mapping and spatial analysis were done using ArcGIS v10.1 software. All other data processing and analysis were done using Stata version 14 software.</p> <p>Results: The proportion of PNC utilization was 6.9 % (95% CI: 6.3%, 7.5%). There are spatial variations among regions in the country. Dire Dawa, Harari, and Jigjiga were with low utilization of PNC, whereas Tigray region utilized PNC highly at 99% confidence level. Factors including, mother with no education (AOR=0.55, 95%CL: 0.37, 0.84) and poorest wealth status (AOR=0.55, 95% CI: 0.39, 0.78) consistently predicted the lack of usage of PNC. In contrast, mothers in 35 – 49 years (AOR: 1.75, 95%CI: 1.01, 3.04) and women with at least one ANC visit (OR=2.37, 95% CI: 1.71, 3.29) were more likely to use PNC.</p> <p>Conclusion: Postnatal care utilization remains public health problem and has spatial variations at the regional level of the country. Uneducated women, young age, and poverty are barriers to PNC utilization. Educational status, wealth status, the age of mothers and ANC visits were predictors for PNC utilization. Hence, health promotion on ANC utilization and other predictors would be supreme important for better utilization of PNC.</p>	1 2

		Keywords: Postnatal Care, Demography and Health Survey, Women, Ethiopia	
Introduction			
Background/rationale	2	<p>In 2015, roughly 66% of the world's maternal mortality was found in Sub-Saharan Africa [1, 2]. A report in Ethiopia showed the presence of a large proportion of maternal and neonatal deaths despite the health system focusing on improving maternal health [3].</p> <p>PNC is used as an indicator of maternal health care in the post-partum period [4]. The World Health Organization (WHO) and Federal Ministry of Health (FMOH) of Ethiopia recommended that mothers must receive postnatal care at least once during the post-partum period [5-7]. Ethiopian health policies focus on maternal and child health care. As a result, maternal mortality rate decreased from 897 to 412 per 100,000 between 2000 and 2016 [6], while the antenatal care (ANC) is increased from 10.4% to 32% [8, 9]. However, PNC utilization remains very low in which only 13 to 26% of women received PNC in the last five years [10].</p> <p>Studies done in developing countries have looked into the factors associated with postnatal care utilization. Mother's Socio-demographic characteristics, including household wealth status, maternal education, maternal occupation, and residence were positively associated with PNC [11,12]. In addition, history of ANC, place of delivery and mother's knowledge of postpartum danger signs and symptoms are important predictors of postnatal care service utilization[13]. On the other hand, PNC service utilization depends on birth-related complication that can end maternal and neonatal death [14-16].</p> <p>The Ethiopian Ministry of Health has developed strategies to improve maternal and child health care utilization which is free of charge [17]. However, it is noted that the magnitude of maternal health services is heterogeneous geographically. Additionally, the extent of key barriers to PNC utilization are unexplored, which are cause maternal and neonatal death during the postnatal period. In Ethiopia, characterizing the spatial distribution of PNC utilization is essential to prioritize risk areas where PNC is needed and facilitate interventions. In another word, Understanding the levels and geographical variations of PNC utilization would help policymakers, planners, programmers and partners in the health sector to formulate appropriate strategies and interventions and provide quality reproductive health services.</p>	3 - 4
Objectives	3	Therefore, this study was aimed to explore geographical variations and identify the determinants of PNC utilization among women after delivery in Ethiopia	4
Methods			

Study design	4	We used Ethiopian Demography and Health Survey (EDHS) 2016 data which was a national representative cross-sectional survey	4
Setting	5	The study was conducted in Ethiopia, the country composed of nine Regional State and two city administrations. The country is the second most populous country in sub-Saharan Africa, with a population of over 100 million people and is a mainly rural country with only 17% of the population living in urban areas [18, 19]. Ethiopia has improvement in the coverage and utilization of the healthcare service after implementation of Health Sector Development Plan (HSDP) through decentralized in three-tier structure. Mainly, health centers provide preventative and basic curative services with referral system to the nearest high level of care [17]. Primary health cares are offered to all women free of charge including PNC in the country. In addition, the health centers composed a number of staffs such as health extension workers and health development army (HDA) to improve Universal Primary Health Care (PHC) coverage at the lowest level of administration.	4
Participants	6	The 2016 EDHS is the fourth Demographic and Health Survey conducted in the country. The study population was any women in childbearing age who gave birth in the last five years residing in the randomly selected enumeration areas (EAs). The study subjects were any women in childbearing age that gave birth in the last five years in Ethiopia.	4
Variables	7	The outcome variable of this study was women’s health check-up after discharge or delivery at home (PNC utilization). Based on WHO guideline, PNC utilization defined as women who received any postpartum check after discharge from health facility or delivery at home and extends up to six weeks (42 days) after birth prior to a survey [7, 21]. The response was dichotomized as “1” if the woman received at least one health check-up after discharge or delivery at home, otherwise assigned “0”. Independent variables were sociodemographic variables (age, educational level, occupation, religion, residence, region, and household wealth quintile), maternal reproductive health-related factors (place of delivery, antenatal care visit, sex of the child and health professions who checked maternal health after discharge or delivery at home).	5
Data sources/ measurement	8*	In Ethiopia, every five years, the Demographic and Health Survey program has collected data on national representative samples of all age group and key indicators including child health and maternal-related variables. Data collection took place from January 18, 2016, to June 27, 2016. EDHS datasets are available in the Measure DHS program website. After reviewing, we extracted 7,193 women data. The national shapefiles were used to maps the variations using ArcGIS 10.1.	5
Bias	9	After survey data extraction, further coding and analysis were done using STATA version 14 software.	5

		Sample weights were used to avoid geographical strata selection variability as well as for non-responses. The detailed explanation of the weighting procedure elsewhere in EDHS final report [22].	
Study size	10	The EDHS 2016 used a stratified two-stage cluster sampling design. The EAs were the primary sampling units and households were the second stage-sampling units. The survey included 15,683 women between ages 15 to 49 years old. A total of 7,193 women gave at least one birth in the last five years preceding the survey were included in the final analysis of this study.	6
Quantitative variables	11	Descriptive measures were used to summarize the overall characteristics of the study participants in the study area.	6
Statistical methods	12	<p>The spatial patterns of PNC were analysed using Geographical Information System (ArcGIS version 10.1) software. The application of GIS with spatial statistics clearly exhibited the spatial pattern of PNC. Spatial Autocorrelation analysis was performed to test whether the cases were distributed randomly over space and identified the pattern of PNC was clustered, dispersed, or random. Moran's I calculated I values as $I=0$ values was for random distribution, $I<0$ values for dispersed, and $I>0$ values for clustered [23].</p> <p>The cluster-outlier analysis (Anselin Local Moran's I) was employed to distinguish between a statistically significant ($p<0.01$) cluster of high values (High-High), cluster of low values (Low-Low), outlier in which a high value is surrounded primarily by low values (High-Low) and outlier in which a low value is surrounded primarily by high values (Low-High) [24]. A positive value for 'I' indicated that features with similar values, such type of feature surrounded the feature was part of a cluster. A negative value for 'I' indicated that features with dissimilar values surrounded the feature. Such a feature was an outlier [25].</p> <p>We applied spatial scan statistical analysis using Kuldorff's SaTScan version 9.4 software [26], to test for the presence of statistically significant spatial clusters of PNC. The spatial scan statistic uses a scanning window that moves across space [24]. The spatial patterns of PNC and its statistical significance was tested by Bernoulli probability model. With the assumption of Bernoulli probability function, we tested the null hypothesis whether there was no difference within the spatial window and outside the window. The default maximum spatial cluster size of $<50\%$ of the population was used, as an upper limit, which allowed both small and large clusters to be detected and ignored clusters that contained more than the maximum limit. For each potential cluster, a likelihood ratio test statistic was used to determine if the number of observed cases within the potential cluster was significantly higher than expected or not. The circle with the maximum likelihood ratio test statistic was defined as the most</p>	6-7

		likely (primary) cluster. The maximum observed value of the test statistic for each potential cluster was then compared with the overall distribution of maximum values. The primary and secondary clusters were identified and assigned p-values and ranked based on their likelihood ratio test, on the basis of 999 Monte Carlo replications [27, 28]. Multilevel binary logistic regression was used to calculate the measures between each of the independent variables (mother and household characteristics) and the likelihood of mothers using PNC services. The rationales for using a multilevel modelling were due to the multistage cluster sampling procedure, individual women were nested within clusters. Hence, the likelihood of women seeking maternal health services is likely to be correlated to the cluster members. Variables that had a relationship with PNC utilization ($p < 0.25$) were considered for the final model. Odds ratios with 95 % CI were used to declare statistical significance.	
Results			
Descriptive data	13*	A total of 7,193 women age 15-49 years who had at least one birth in the five years before the study period were included in the analysis. The majority 6621 (87.2%) of the respondents were rural residents. The mean age of the respondents was 29.26 years (SD ± 6.9). About 4791(63.1%) of the respondents had no education and about one-third of the respondents were in the poorest wealth quintile. The majority of the participants were from Oromia Regional State3130 (41.2%), followed by1633 (21.5 %) Amhara Regional State and SNNP 1601(21.1%).	7
Outcome data	14*	The proportion of postnatal health check-up after discharge or home delivery was found to be 6.9% (95% CI: 6.3%, 7.5%), with urban, 10.6% (95% CI: 9.1, 12.2), and rural 5.9% (95% CI: 5.3, 6.6)). PNC service utilization varied across the regions of the country with the highest proportion (15%) in Tigray regional state and lowest proportion (3%) in Gambella and Somali Regional State. The proportion of women’s health check-up after discharge or delivery at home in the women having antenatal care at least four visits was 10.5 % and, in the women, who delivered at a health facility, was 9.1 % (Table 1).	7
Main results	15	The global Moran’s index statistic was 0.084 (p-value < 0.0001), indicating the presence of a significant positive spatial autocorrelation in women’s health check-up after discharge or delivery at home in Ethiopia (Figure 1). The spatial clustering is highly pronounced at a distance of 225.2 KMs with a corresponding Z score of 12.592741 (P-value <0.0001) (Figure 2). According to LISA analysis, high clusters were observed in the major part of Tigray region (Central, eastern, western and southern Tigray) at 99% confidence level, but at 95%CI it was found at Addis Ababa town, western Tigray, North Shewa, south Shewa and East Gojjam zone of Amhara regional state, Arsis zone of Oromia region and Gurage	8-9

		<p>zone of SNNP region. In contrast, low significant clustering of women's health check-up after discharge or delivery at home were major parts of Gambella region, Harari, jigjig and Eastern Haragie (Figure 3). The SaTScan spatial analysis was identified three clusters. The primary clusters (LLR = 20.72, $p < 0.0001$) were detected in Southeastern Ethiopia. A second cluster (LLR = 19.36, $P < 0.0001$) were detected in east of Ethiopia. The final cluster (LLR = 10.91, $P = 0.048$), were in Northern Ethiopia (Table2, Figure 4).</p> <p>Despite all observations were low, relatively the highest percentage of women's health check-up after discharge or delivery at home was observed in Tigray region, 15.6% and Addis Ababa, 13.1%%, whereas the lowest observation in Somali (3.0%), Oromia (3.6%) and Afar (4.2%) (Figure 5).</p> <p>Factors associated with PNC utilization</p> <p>Demographic and socio-economic variables were selected using Enter methods at 0.25 significance level. In the final model, maternal education, wealth index and ANC visit were identified as associated factors with women's health check-up after deliver.</p> <p>Level of education showed strong statistical association with postnatal care service utilization. Mothers who have no education were about 33% times (AOR=0.55, 95%CL: 0.37, 0.84) less likely to utilize postnatal care service than educated (above Secondary) women. Similarly, the odds of poorest decreased the chance of utilizing postnatal care service by about one-third fold (AOR=0.55, 95% CI: 0.39, 0.78) less likely than richest women.</p> <p>Age of women has also been an important predictor of postnatal care service utilization. Mothers who age group in 35 – 49 years were about 1.75 times (AOR: 1.75, 95%CI: 1.01, 3.04) more likely to utilize postnatal care service utilization than younger than 19 years. Postnatal care service utilization also increased with increasing ANC visits of mothers. Women who had one to three ANC visit (OR=2.37, 95% CI: 1.71, 3.29) were more likely to receive health check-up after delivery than no Antenatal Care. Moreover, Mothers who had fourth ANC visit were about 3-fold (AOR: 3.43, 95%CI: 2.47, 4.76) more likely to utilize postnatal care service than those who had no any type of ANC visits (Table 3).</p>	
Discussion			
Key results	16	<p>Postnatal care utilization among women in Ethiopia was low and varied across socio-demographic characteristics. Regional disparity (Spatial pattern) was observed in postnatal care utilization among Ethiopian women. Higher educational level, better wealth index, antenatal care at least one visit and place of delivery were significant predictors of postnatal care utilization among women in Ethiopia. Thus, there is a need to devise such strategies, ensuring availability, accessibility and affordability of</p>	11

		<p>PNC for mother and newborn considering geographical difference. Emphasis should be given on designing public health interventions to educate and raise awareness among mothers and families regarding importance of PNC, timing for PNC check-up.</p>	
<p>Limitations</p>	<p>17</p>	<p>The study has addressed PNC utilization and spatial disparity; however, it has the following limitations. First, the analysis is designed to identify predictors of PNC and spatial patterns, but it does not point directly to explanations for these outcomes. This is a less helpful for explaining causality. Secondly, the study was represented the experiences of the participants in the 5 years that followed the study period. This might lead to recall biases, which in turn the findings may not be generalizable. Finally, there may be unmeasured variables that predict the outcomes. One example is health facility related factors like quality of services. Further research should consider the potentially important predictors.</p>	<p>10</p>
<p>Interpretation</p>	<p>18</p>	<p>This study was investigated factors and spatial variations of postnatal care utilizations among Ethiopian women using the 2016 Ethiopian DHS data.</p> <p>The study showed that Ethiopia continued to have low proportion of postnatal care (PNC) utilization. The finding was smaller than 2011 EDHS [8, 12] that indicated maternal and child health remains poor. This may be attributed to the samples difference and could be improvement in quality of data to date. It was found to below with studies done in Amhara region, Ethiopia [14, 29] and southern Ethiopia [30]. The difference might be due to our study include rural areas and study characteristics. This low result may be attributed by Programmatic problem impact on a woman's making a PNC visit and low exposure to the mass media. In comparison with other countries, Ethiopia is behind in postnatal care (PNC) utilization; including Kenya (47%)[31, 32], Nigeria (29%)[33], Nepal (40.9%)[11] and Tanzania (10.5%)[34]. This variation can also be attributed due to the time difference and could be improvement in health care utilization conducted in Kenya unlike to our study. The postnatal care (PNC) utilization is varies geographically in Ethiopia. Specifically, Tigray region and Addis Ababa city have hotspot areas. The study found that PNC was considerably varied in demographic characteristics; for example, 57% women who delivered at health facility, Orthodox religion (12.9%) and Addis Ababa residents (51.6%) were more user and PNC utilization was directly increased as level of maternal education and wealth index. This Study consistent studies conducted in Ghana and India found some geographic variations in socioeconomic inequalities [35, 36].</p> <p>This study identified several factors that indicate strong influence on the utilization of PNC services: age of mother, mother's level of education, household wealth quintile and ANC visit. Those women with no education less likely to use postnatal care as compared to women who educated more than secondary school. This finding is consistent with Nigeria [37], Kenya [32] and Nepal [11], Ethiopia[12, 14, 30, 38,</p>	<p>9-10</p>

		<p>39] and India [36]. This could be explained by the fact that education has a valuable input in enhancing female autonomy and help women develop greater confidence and capability to make decisions about their own health. Thus, literate women seek out higher quality health services and have greater ability to use health care inputs that offer better health outcomes.</p> <p>Similarly, Women in poorest wealth quintile level were less likely to use PNC as compared to richest wealth quintile in attending at least one postnatal care visit. This study is similar with evidence from study conducted in Ethiopia [12]. Our finding is also in line with others studies: Pakistan [40], Nepal and Rwanda[11, 41]. Richest Women’s may get more information of Children’s Health from mass media and health professionals privately subsequently; families may arrange institutional health services.</p> <p>Postnatal care utilization was positively associated with antenatal care service. That is Mothers who attended ANC services more frequently were more likely to receive PNC services compared to those who had attended less than one ANC services. This finding is similar with study in Nepal[11], India[36]Tanzania [34] and Kenya [32].The possible reason may be ANC users perceived that health system has provided quality care based on previous experiences. Furthermore, this could be due to variations of socio-demographic, cultural differences, which may lead to health service related to pregnancies.</p> <p>In this study, we found that mother’s older age at delivery was positively associated with PNC use. Our finding is contrast with study done in Rwanda[41]. The main reason is differences in cultural. In Ethiopia, older women were more involved in their own health care decision-making and respected than younger women. This may be reinforced that women who are empowered to make health care choices previous experiences and then older women more likely to use PNC services.</p>	
Generalisability	19	This study was a national representative in Ethiopia.	
Other information			
Funding	20	No funds received for the present study	

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Spatial Patterns and Determinants of Postnatal Care Use in Ethiopia: Findings from the 2016 Demographic and Health Survey

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2 **Spatial Patterns and Determinants of Postnatal Care Use in Ethiopian: Findings from the**
3 **2016 Demographic and Health Survey**
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Abstract

Objective: In Ethiopia, despite postnatal care (PNC) is essential for preventing maternal and newborn deaths, it still remains worrisome. This study was aimed to explore geographical variations and identify the determinants of PNC utilization among women after delivery in Ethiopia.

Methods: The 2016 Ethiopian Demographic and Health Survey data were used to investigate the determinants of postnatal care utilization among 7,193 women data who receive a health checkup after discharge and home delivery across the country. A multilevel logistic regression model was used to identify predictors of PNC utilization. Odds ratio with 95% confidence intervals were calculated to determine statistical significance. Spatial analysis was done using ArcGIS v10.1, while all other data processing and analysis were done in Stata 14.

Results: The proportion of PNC utilization was 6.9 % (95% CI: 6.3%, 7.5%). Spatial variations were observed. Dire Dawa, Harari, and Jigjiga were with low utilization, whereas Tigray region utilized PNC higher at 99% confidence level. Factors including, mother with no education (AOR=0.55, 95%CL: 0.37, 0.84) and poorest wealth status (AOR=0.55, 95% CI: 0.39, 0.78) consistently predicted the lack of usage of PNC. In contrast, mothers in 35 – 49 years (AOR: 1.75, 95%CI: 1.01, 3.04) and women with at least one ANC visit (OR=2.37, 95% CI: 1.71, 3.29) were more likely to use PNC.

Conclusion: Postnatal care utilization remains a public health problem and has spatial variations at the regional level of the country. Women who have low levels of education, adults age group, poorest wealth index status and having a history of ANC visit are significantly more likely to use postnatal care than their counterparts. Hence, health promotion on ANC utilization and other predictors would be supreme importance for better utilization of PNC.

Keywords: Postnatal Care, Primary Care, Public Health, Demography and Health Survey, Maternal Medicine

Strengths and limitations of this study

- The study used a national large-scale data and applied advanced approach.
- It is potential for cross-country comparison and interventions.
- As a cross-sectional survey, we are unable to draw causal conclusions.
- The study has presented the experiences of the participants in the 5 years that followed the study period. This might lead to recall bias, which in turn the findings may not be generalizable.
- As a secondary data analysis, some important variables were not available for analysis such as cultural beliefs about when women are allowed to leave the house in the postpartum period, roles of husbands in maternal health decision-making, and perceptions about whether pregnancy is a medical issue warranting clinical visits.

Background

In 2015, roughly 66% of the world's maternal mortality were found in Sub-Saharan Africa [1, 2]. A report in Ethiopia showed the presence of a large proportion of maternal and neonatal deaths despite the health system, focusing on improving maternal health [3, 4].

PNC is used as an indicator of maternal health care in the post-partum period [5]. According to World Health Organization (WHO), postnatal period is critical for both mother and baby that all women and newborns receive at least three postnatal contacts following delivery [6-8]. Since, postnatal cares is an opportunity for providers to facilitate healthy breastfeeding practices, screen for postpartum depression, monitor the newborn's growth and overall health status, treat childbirth-related complications, counsel women about their family planning options and refer the mother and baby for specialized care if necessary, among other services. In Ethiopian, maternal mortality rate decreased from 897 to 412 per 100,000 between 2000 and 2016 [7], while the antenatal care (ANC) is increased from 10.4% to 32% [9, 10]. However, PNC utilization remains very low in which only 13 to 26% of women received PNC in the last five years [11].

Studies done in developing countries have looked into the factors associated with postnatal care utilization. Mother's Socio-demographic characteristics, including household wealth status, maternal education, maternal occupation, and residence were positively associated with PNC [12, 13]. In addition, a history of ANC, place of delivery and mother's knowledge of postpartum danger signs and symptoms are important predictors of postnatal care service utilization [14].

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2 On the other hand, the PNC service utilization depends on birth-related complication that can
3 end maternal and neonatal death [15-17].
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5 While there have been efforts to improve health coverage and expenditures expanded
6 universally; however, important maternal health inequities are concealed in smaller
7 administrative areas. Currently, the Ethiopia health care strategy is focused on primary health
8 care units included health centers, health stations, health posts and private clinics. However, it
9 is noted that the magnitude of maternal health services is heterogeneous geographically.
10 Additionally, the extent of key barriers to PNC utilization is unexplored, which are caused
11 maternal and neonatal death during the postnatal period. In Ethiopia, characterizing the spatial
12 distribution of PNC utilization is essential to prioritize risk areas to interventions. In another
13 word, understanding the levels and geographical variations of PNC utilization would help to
14 improve the availability and quality of postnatal care. Moreover, mapping of the variation in
15 PNC can help in improving programs in terms of the allocation of limited resources to those
16 regions with high-unmet needs of healthcare. Typically, spatial analysis has the ability to
17 integrate data on health-related social and environmental risk factors in explaining the
18 variations of maternal health outcomes. As well as elucidating risk factors for adverse maternal
19 events, has become increasingly apparent. On the other hand, maternal and child health
20 outcome disparities are not well addressing associated with utilization of postpartum care.
21 Therefore, this study aimed to explore geographical variations and identify the determinants of
22 PNC utilization among women after delivery in Ethiopia.
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37 **Methods**

38 **Data Source**

39 The study was conducted in Ethiopia, located in sub-Saharan Africa. Ethiopia has a nine
40 regional state and two city administrations with over 100 million population and is a mainly rural
41 country with only 17% of the population living in urban areas [18, 19]. In Ethiopia, health care
42 service has been improved after implementation of the Health Sector Development Plan
43 (HSDP) through decentralized in three-tier structure. Mainly, health centers provide
44 preventative and basic curative services with the referral system to the nearest high level of
45 care [4]. Primary health cares are offered to all women free of charge, including PNC
46 throughout in the country. In addition, the health centers composed a number of staffs such as
47 health extension workers and health development army (HDA) to improve Universal Primary
48 Health Care (PHC) coverage at the lowest level of administration.
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2 The data used for this study were drawn from the 2016 Ethiopia Demographic and Health
3 Survey (2016 EDHS), which is a nationally representative survey. The 2016 EDHS was
4 conducted by the Central Statistical Agency (CSA) with funding support from the government of
5 Ethiopia, the United States Agency for International Development (USAID), the government of
6 the Netherlands, the Global Fund, Irish Aid, the World Bank, the United Nations Population
7 Fund (UNFPA), the United Nations Children's Fund (UNICEF), and UN Women. ICF
8 International provided technical support [20].

13 **Patient and Public Involvement**

14
15 The 2016 EDHS sample was selected using a two stage stratified design consisting of 645
16 enumeration areas (EAs) (202 EAs in urban areas and 443 EAs in rural areas). In the 2016
17 EDHS dataset, 17,067 households were selected, of which 16,650 were interviewed. Data
18 analyses were from 7,193 women of childbearing age (15–49 years).

19 Although different covariates on population and health issues in Ethiopia were presented in the
20 comprehensive and well-detailed data set, we focused on women's health checkup after
21 discharge or delivery at home (PNC utilization) as the dependent variable. Based on WHO
22 guideline, PNC utilization defined as women's who received postnatal health checkup after
23 health facility discharge or home delivery and extends up to six weeks (42 days) after birth prior
24 to a survey [8, 21]. The response was dichotomized as "1" if the woman received at least one
25 health checkup after discharge or delivery at home to the most recent birth, otherwise assigned
26 "0". The choice of explanatory variables was guided by the literature. The independent variables
27 were sociodemographic variables (age, educational level, occupation, religion, residence,
28 region, and household wealth quintile), maternal reproductive health-related factors (place of
29 delivery, number of antenatal care visits, sex of the child and health professions who checked
30 maternal health after discharge or delivery at home.

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32 The survey also collected geographic data at all sample points (called "EAs"). These
33 geographic coordinates were later linked to the Demographic and Health Survey (DHS) dataset
34 in our study. These data were obtained from the database of Measure DHS and
35 converted to the Ethiopia metric grid projected coordinate system using ArcGIS 10.1
36 software.

37 **Data analysis**

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39 After data extraction, further coding and analysis was done using STATA version 14 software.
40 Sample weights were used to avoid geographical strata selection variability as well as for non-
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2 responses. The detailed explanation of the weighting procedure elsewhere in the EDHS final
3 report [22].
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5 Descriptive measures were used to summarize the overall characteristics of the study
6 participants in the study area. Multilevel binary logistic regression was used to calculate the
7 measures between each of the independent variables (mother and household characteristics)
8 and the likelihood of mothers using PNC services. The rationales for using a multilevel
9 modeling were due to the multistage cluster sampling procedure, individual women were nested
10 within clusters. We used the region as cluster variables. Hence, the likelihood of women
11 seeking maternal health services is likely to be correlated to the cluster members. Variables
12 that had a relationship with PNC utilization ($p < 0.25$) were considered for the final model. Odds
13 ratios with 95 % CI were used to declare statistical significance.
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21 **Spatial Data analysis**

22 To investigate geographical variability in the association between utilization of postnatal care
23 and socioeconomic background of Ethiopian women, we used spatial statistics. Spatial
24 autocorrelation analysis was performed to test whether the cases were distributed randomly
25 over space and identified the pattern of the PNC was clustered, dispersed, or random [23-25].
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28 The cluster-outlier analysis (Anselin Local Moran's I) was employed to distinguish between a
29 statistically significant ($p < 0.01$) cluster of high values (High-High), cluster of low values (Low-
30 Low), outlier in which a high value is surrounded primarily by low values (High-Low) and outlier
31 in which a low value is surrounded primarily by high values (Low-High) [26]. A positive value for
32 'I' indicated that features with similar values, such type of feature surrounded the feature was
33 part of a cluster. A negative value for 'I' indicated that features with dissimilar values
34 surrounded the feature. Such a feature was an outlier [27].
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41 We applied spatial scan statistical analysis using Kuldorff's SaTScan version 9.4 software to
42 test for the presence of statistically significant spatial clusters of PNC across space based on
43 Bernoulli probability model [28]. With the assumption of Bernoulli probability function, we tested
44 the null hypothesis whether there was no difference within the spatial window and outside the
45 window. The default maximum spatial cluster size of <50% of the population was used, as an
46 upper limit, which allowed both small and large clusters to be detected and ignored clusters that
47 contained more than the maximum limit. For each potential cluster, a likelihood ratio test
48 statistic was used to determine if the number of observed cases within the potential cluster was
49 significantly higher than expected or not. The circle with the maximum likelihood ratio test
50 statistic was defined as the most likely (primary) cluster, then compared with the overall
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2 distribution of maximum values. The primary and secondary clusters were identified and
3 assigned p-values and ranked based on their likelihood ratio test, on the basis of 999 Monte
4 Carlo replications [29, 30].
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8 9 Results

10 Socio-Demographic characteristics of the study subjects

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12 A total of 7,193 women age 15-49 years who had at least one birth in the five years before the
13 study period were included in the analysis. The majority 6621 (87.2%) of the respondents were
14 rural residents. The mean age of the respondents was 29.26 years (SD \pm 6.9). About 4791
15 (63.1%) of the respondents had no education and about one-third of the respondents were in
16 the poorest wealth quintile. The majority of the participants were from Oromia Regional
17 State 3130 (41.2%) followed by 1633 (21.5 %) Amhara Regional State and SNNP 1601 (21.1%).
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24 Postnatal Care coverage

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26 The proportion of postnatal health checkup after discharge or home delivery was found to be
27 6.9% (95% CI: 6.3%, 7.5%), with urban, 10.6% (95% CI: 9.1, 12.2), and rural 5.9% (95% CI:
28 5.3, 6.6)). PNC service utilization varied across the regions of the country with the highest
29 proportion (15%) in Tigray regional state and lowest proportion (3%) in Gambella and Somali
30 Regional State. The proportion of women's health checkup after discharge or delivery at home
31 in the women having the antenatal care at least four visits was 10.5 % and, in the women, who
32 delivered in a health facility was 9.1 % (**Table 1**).
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40 Spatial distribution of PNC Utilization

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42 The global Moran's index statistic was 0.084 (p-value < 0.0001), indicating the presence of a
43 significant positive spatial autocorrelation in women's health checkup after discharge or delivery
44 at home in Ethiopia (**Figure 1**). The spatial clustering is highly pronounced at a distance of
45 225.2 Kms with a corresponding Z score of 12.592741 (P-value <0.0001). According to LISA
46 analysis, high clusters were observed in the major part of Tigray region (Central, eastern,
47 western and southern Tigray) at the 99% confidence level, but at 95%CI it was found in Addis
48 Ababa town, western Tigray, North Shewa, South Shewa and East Gojjam zone of Amhara
49 regional state, Arsis zone of Oromia region and Gurage zone of SNNP region. In contrast, low
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2 significant clustering of women's health checkup after discharge or delivery at home were major
3 parts of Gambella region, Harari, Jigjig and Eastern Haragie.
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6 Moreover, the SaTScan spatial analysis was identified three clusters. The primary clusters (LLR
7 = 20.72, $p < 0.0001$) were detected in Southeastern Ethiopia. A second cluster (LLR = 19.36,
8 $P < 0.0001$) was detected in east of Ethiopia. The final cluster (LLR = 10.91, $P = 0.048$), were in
9 Northern Ethiopia (**Table2, Figure 2**).
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13 Despite all observations were low, relatively the highest percentage of women's health checkup
14 after discharge or delivery at home was observed in Tigray region, 15.6% and Addis Ababa,
15 13.1%%, whereas the lowest observed in Somali (3.0%), Oromia (3.6%) and the Afar (4.2%)
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17 (**Figure 3**).
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20 21 **Factors associated with PNC utilization**

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23 Demographic and socioeconomic variables were selected using Enter methods at 0.25
24 significance level. In the final model, maternal education, wealth index and ANC visit were
25 identified as associated factors with women's health checkup after delivery.
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29 Level of education showed strong statistical association with postnatal care service utilization.
30 Mothers who have no education were about 33% times (AOR=0.55, 95%CL: 0.37, 0.84) less
31 likely to utilize postnatal care service than educated (above Secondary) women. Similarly, the
32 odds of poorest decreased the chance of utilizing postnatal care service by about one-third fold
33 (AOR=0.55, 95% CI: 0.39, 0.78) less likely than richest women.
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37 The age of women has also been an important predictor of postnatal care service utilization.
38 Mothers who age group in 35 – 49 years were about 1.75 times (AOR: 1.75, 95%CI: 1.01, 3.04)
39 more likely to utilize postnatal care service utilization than younger than 19 years. Postnatal
40 care service utilization also increased with increasing ANC visits of mothers. Women who had
41 one to three ANC visit (OR=2.37, 95% CI: 1.71, 3.29) were more likely to receive health
42 checkup after delivery than no Antenatal Care. Moreover, Mothers who had a fourth ANC visit
43 were about 3-fold (AOR: 3.43, 95%CI: **2.47, 4.76**) more likely to utilize postnatal care service
44 than those who had no any type of ANC visits (**Table 3**).
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52 53 **Discussion**

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55 This research has found substantial spatial variation across the regions and identified the "Hot
56 spots" characterized by a higher PNC utilization rate compared to "Cold Spots" characterized by
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2 a low PNC utilization rate in Ethiopia. As well as, women who have low levels of
3 education, adults age group (35- 49), poorest wealth index status and having a history of ANC
4 visit are significantly more likely to use postnatal care than their counterparts.
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8 The study showed that Ethiopia continued to have a low proportion of postnatal care utilization.
9 The finding was smaller than 2011 EDHS [9, 13] that indicated maternal and child health
10 remains poor. This may be attributed to the samples difference and could be an improvement in
11 the quality of data to date. It was found to below with studies done in Amhara region, Ethiopia
12 [15, 31] and southern Ethiopia [32]. The difference might be due to our study include rural areas
13 and sociocultural characteristic variations. This low result may be attributed by Programmatic
14 problem impact on a woman's making a PNC visit and low exposure to the mass media. In
15 comparison with other countries, Ethiopia is behind in postnatal care utilization; including Kenya
16 (47%) [33, 34], Nigeria (29%) [35], Nepal (40.9%) [12] and Tanzania (10.5%) [36]. This variation
17 can also be attributed due to the time difference and could be an improvement in health care
18 utilization conducted in Kenya unlike to our study. The postnatal care utilization is varied
19 geographically in Ethiopia. Specifically, Tigray region and Addis Ababa city have hotspot areas.
20 The study found that PNC was considerably varied in demographic characteristics; for example,
21 57% women who delivered in a health facility, Orthodox religion (12.9%) and Addis Ababa
22 residents (51.6%) were more user and PNC utilization was directly increased as the level of
23 maternal education and wealth index. This Study consistent study conducted in Ghana and
24 India found some geographic variations in socioeconomic inequalities [37, 38].
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38 This study identified several factors that indicate a strong influence on the utilization of PNC
39 services: age of the mother, the mother's level of education, household wealth quintile and ANC
40 visit. Those women with no education least likely to use postnatal care as compared to women
41 who educated more than secondary school. This finding is consistent with Nigeria [39], Kenya
42 [34] and Nepal [12], Ethiopia [13, 15, 32, 40, 41] and India [38]. This could be explained by the
43 fact that education has a valuable input in enhancing female autonomy and help women
44 develop greater confidence and capability to make decisions about their own health. Thus,
45 literate women seek out higher quality health services and have greater ability to use health
46 care inputs that offer better health outcomes.
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54 Similarly, Women in the poorest wealth quintile level were less likely to use PNC as compared
55 to richest wealth quintile in attending at least one postnatal care visit. This study is similar to
56 evidence from a study conducted in Ethiopia [13]. Our finding is also in line with others studies:
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2 Pakistan [42], Nepal and Rwanda [12, 43]. Richest Women's may get more information about
3 Children's Health from mass media and health professionals privately subsequently; families
4 may arrange institutional health services.
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8 Postnatal care utilization was positively associated with antenatal care service. That is mothers
9 who attended ANC services more frequently were more likely to receive PNC services
10 compared to those who reported not receiving any ANC. This finding is similar to study in Nepal
11 [12], India [38], Tanzania [36] and Kenya [34]. The possible reasons for the positive effects of
12 ANC on PNC is that ANC offers women an entry point to the health care system as well as
13 providing counselling and awareness of the benefits of PNC. Additionally, if the ANC
14 experience was positive, then women are more eager to attend a PNC visit. Furthermore, this
15 could be due to variations of socio-demographic, cultural differences, which may lead to seek
16 health service related to pregnancies.
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20 In this study, we found that mother's older age at delivery was positively associated with PNC
21 use. Our finding contrasts with a study done in Rwanda [43]. The main reason is differences in
22 culture. In Ethiopia, adult women were more involved in their own health care decision-making
23 and respected than younger women. This may be reinforced that women who are empowered
24 to make health care choices previous experiences and then adult women more likely to use
25 PNC services.
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29 The study has addressed PNC utilization and spatial disparity; however, it has the following
30 limitations. First, the analysis is designed to identify predictors of PNC and spatial patterns, but
31 it does not point directly to explanations for these outcomes. As a cross-sectional survey, we
32 are unable to draw causal conclusions. Secondly, the study has represented the experiences of
33 the participants in the 5 years that followed the study period. This might lead to recall bias,
34 which in turn the findings may not be generalizable. Finally, there may be unmeasured
35 variables that predict the outcomes. One example is health facility-related factors which include
36 quality of services. Further research should consider the potentially important predictors.
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41 **Conclusion:** Postnatal care utilization among women in Ethiopia was low and varied across
42 socio-demographic characteristics. Regional disparity (Spatial pattern) was observed in
43 postnatal care utilization among Ethiopian women. Higher educational level, better wealth
44 index, antenatal care at least one visit and place of delivery were significant predictors of
45 postnatal care utilization among women in Ethiopia. Thus, there is a need to devise such
46 strategies, ensuring availability, accessibility and affordability of PNC for mother and newborn
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2 considering the geographical difference. Emphasis should be given to designing public health
3 interventions to educate and raise awareness among mothers and families regarding the
4 importance of PNC, timing for PNC check-up.
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7 **List of abbreviations**

9	ANC	Antenatal Care
10	CI	Confidence Interval
11	CSA	Central Statistical Agency
12	DHS	Demographic and Health Survey
13	EA	Enumeration Area
14	EDHS	Ethiopia Demographic and Health Survey
15	FMOH	Federal Ministry of Health
16	OR	Odds Ratio
17	PNC	Post Natal Care
18	SD	Standard Deviation
19	SNNP	Southern Nations Nationalities and Peoples
20	SPSS	Statistical Software for Social Science
21	WHO	World Health Organization
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29 **Declarations**

31 **Ethics consents**

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34 Permission consent was obtained to access the 2016 Ethiopia Demographic and Health Survey
35 from Measure DHS International Program, which authorized the data sets. All data were
36 extracted without having any personal identifying information that could be linked to particular
37 individuals, communities, or study participants. As the study was secondary data analysis, the
38 research ethics was waived. Confidentiality of data maintained anonymously.
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44 **Consent for publication**

45
46 Not applicable.
47

48 **Availability of data and material**

49
50 All relevant data are available within the manuscript. However, the minimal data underlying all
51 the findings in the manuscript will be available upon request.
52
53
54

55 **Competing interests**

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57
58 The authors declare that they have no competing interests.
59

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Authors' contributions

TT, YW, AT and DK conceptualized and designed the study. MM, MF, TT, YW, AT and DK carried out the literature review, data extraction and analysis. MM drafted the manuscript. KA, TA, AA and MF participate in data analysis and reviewed the manuscript. All authors read and approved the final version of the manuscript.

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Table 1: Postnatal care use by background characteristics among women age 15-49 who had given birth in the five years preceding the survey, EDHS 2016

Background Characteristics		PNC Use (%)	Total number of women PNC Use	
			Weighted	Unweighted
Age (in Years)	15 - 19	4.4	338	358
	20 - 34	6.6	5291	5041
	35 - 49	5.8	1960	1794
Religion	Orthodox Christian	9.4	2882	2369
	Muslim	4.0	2824	3324
	Protestant	5.5	1652	1338
	Others*	0.9	232	162
Residence	Urban	12.1	969	1512
	Rural	5.5	6621	5681
Region	Tigray	15.6	538	772
	Afar	4.2	71	647
	Amhara	8.0	1633	764
	Oromia	3.6	3130	1031
	Somali	3.0	269	806
	Benishangul	7.4	81	576
	SNNPR	6.3	1601	893
	Gambella	4.8	21	534
	Harari	11.1	18	411
	Addis Ababa	13.6	198	375
	Dire Dawa	9.1	33	384
Maternal Education	No education	4.8	4791	4359
	Primary	7.7	2150	1942
	Secondary	11.9	420	577
	Higher	13.5	229	315
Husband/partner's education level	No education	4.9	3345	3136
	Primary	6.6	2731	2160
	Secondary	9.3	612	745
	Higher	10.9	376	569
	Don't know	9.3	43	52
Wealth index	Poorest	3.1	1652	2428
	Poorer	3.9	1654	1179
	Middle	5.9	1588	1028
	Richer	8.3	1426	917

	Richest	11.8	1269	1641
ANC Visit	No ANC Visit	2.4	2818	2481
	ANC one to three visits	6.6	2342	2092
	ANC at least four visits	10.5	2429	2620
Place of Delivery	Health facility	9.1	2408	2699
	Other than Health facility	5.0	5181	4494
Sex of child	Male	5.8	3941	3718
	Female	6.8	3649	3475
Child Wanted	Wanted then	5.9	5573	5741
	Wanted later	7.9	1321	991
	Wanted no more	6.0	695	461
Birth Order	1	7.1	1434	1470
	2 - 3	7.2	2281	2217
	4 - 5	6.0	1752	1638
	6+	5.0	2122	1868

*Catholic, Traditional and other unclassified

Table 2: Cold spot areas of SaTScan spatial analysis result of Women's health checkup after discharge or delivery at home in Ethiopia from EDHS 2016 data

Cluster	Zone	Coordinates/Radius	LLR*	P Value
1	Nuer and Agnuak administrative zones of Gambella region, Sheka, Majang, Keffa, Benchi Maji, Konta, Dawro, South Omo and Basketo Gamo goffa Administrative zones of SNNP region and Kelem Wollega, West Wolega, East Wollega, Kemash and Jimma administrative zones of Oromiya region	7.396504 N, 35.260203 E / 225.20 km	18.07	< 0.0001
2	Doolo, Korahe, jarar and Nogab administrative zones of Somali Region, Borena, Guji, Bale, West Arsi, West and East Hararge administrative zones of Oromiya region and Gedio & Sidama administrative zones of SNNP.	4.180558 N, 42.052871 E / 467.62 km	14.19	< 0.001
3	Bale and Guji administrative zones of Oromiya Region, Liben, Afder and Shabelle administrative Zones of Somali region	4.180558 N, 42.052871 E / 282.34 km	10.28	0.024

*Log Likelihood ratio

Table 3: Factors Associated with PNC utilization among Women giving birth in the 5 years preceding the survey who had their 1st postnatal checkup within the 1st 42 days after delivery in Ethiopia, EDHS 2016.

Variables		PNC use		COR (95% CI)	AOR (95% CI)
		Yes	No		
Maternal Education	Above Secondary	45	270	1	1
	No Education	226	4,133	0.39(0.27, 0.56)	0.55(0.37, 0.84)
	Primary	158	1,784	0.57(0.39, 0.83)	0.69(0.46, 1.01)
	Secondary	67	510	0.81(0.54, 1.23)	0.87(0.57, 1.315)
Age (in Years)	15 - 19	16	342	1	1
	20 - 34	351	4,690	1.47(0.88, 2.47)	1.47(0.87, 2.48)
	35 - 49	129	1,665	1.46(0.85, 2.51)	1.75(1.01, 3.04)
Religion	Orthodox Christian	246	2,123	1	
	Muslim	179	3,145	0.83(0.63, 1.11)	
	Protestant	69	1,269	0.78(0.54, 1.14)	
	Others*	2	160	0.18(0.04, 0.75)	
Residence	Urban	160	1,352	1	
	Rural	336	5,345	0.60(0.47, 0.76)	
Wealth Index	Richest	180	1,461	1	1
	Poorest	87	2,341	0.39(0.28, 0.547)	0.55(0.39, 0.78)
	Poorer	74	1,105	0.64(0.45, 0.89)	0.75(0.54, 1.056)
	Middle	75	953	0.77(0.55, 1.07)	0.85(0.61, 1.19)
	Richer	80	837	1.06(0.78, 1.45)	0.94(0.63, 1.407)
ANC visit	No Antenatal Care	58	2,423	1	1
	ANC one to three visit	141	1,951	2.58(1.88, 3.54)	2.37(1.71, 3.29)
	ANC at four visits	297	2,323	4.09(3.01, 5.549)	3.43(2.47, 4.76)
Sex of child	Male	233	3,485	1	
	Female	263	3,212	1.20(1.00, 1.45)	
Place of Delivery	Health Facility	266	2,433	1	
	Otherthan Health Facility	230	4,264	0.67(0.54, 0.82)	

*Catholic, Traditional and other unclassified

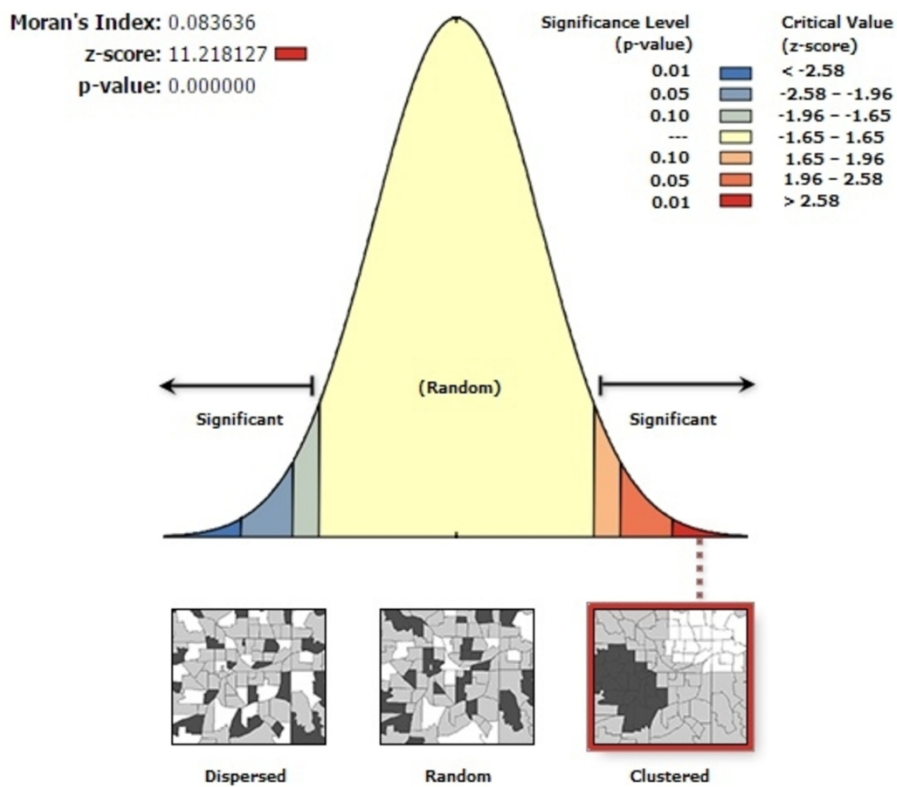
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Figure 1: Spatial autocorrelation based on feature locations and attribute values using the Global Moran's I statistic.

Figure 2: Spatial Clustering of Women's health checkup after discharge or delivery at home in Ethiopia, EDHS 2016

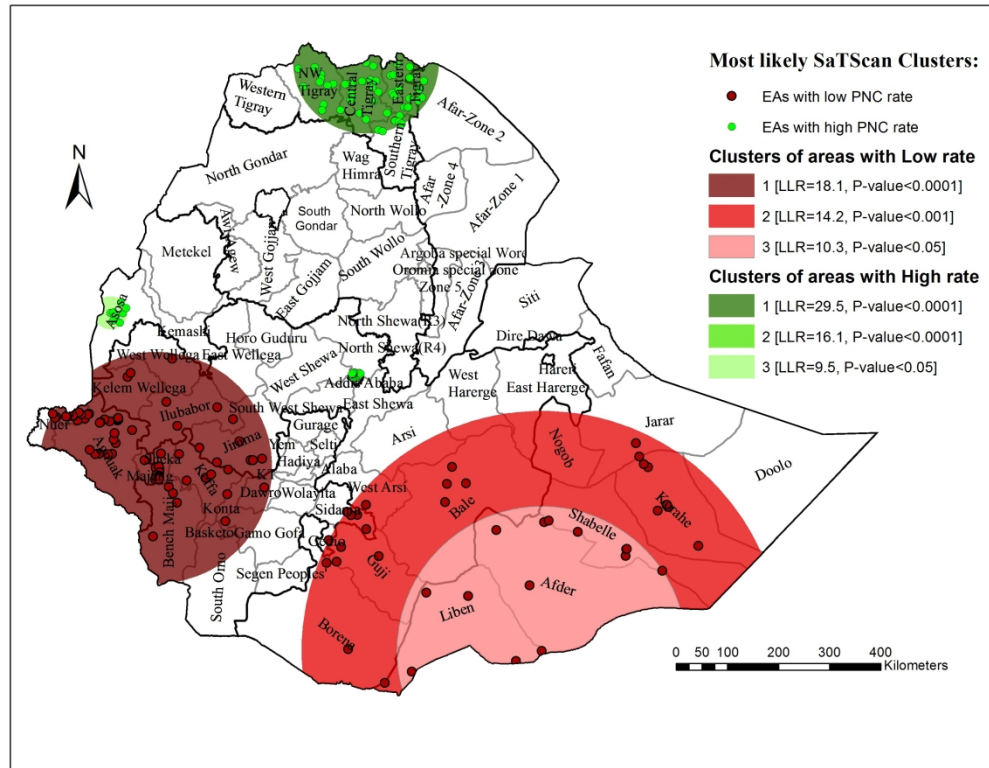
Figure 3: Spatial distribution of Women's health checkup after discharge or delivery by percentages, Ethiopia, EDHS 2016

For peer review only



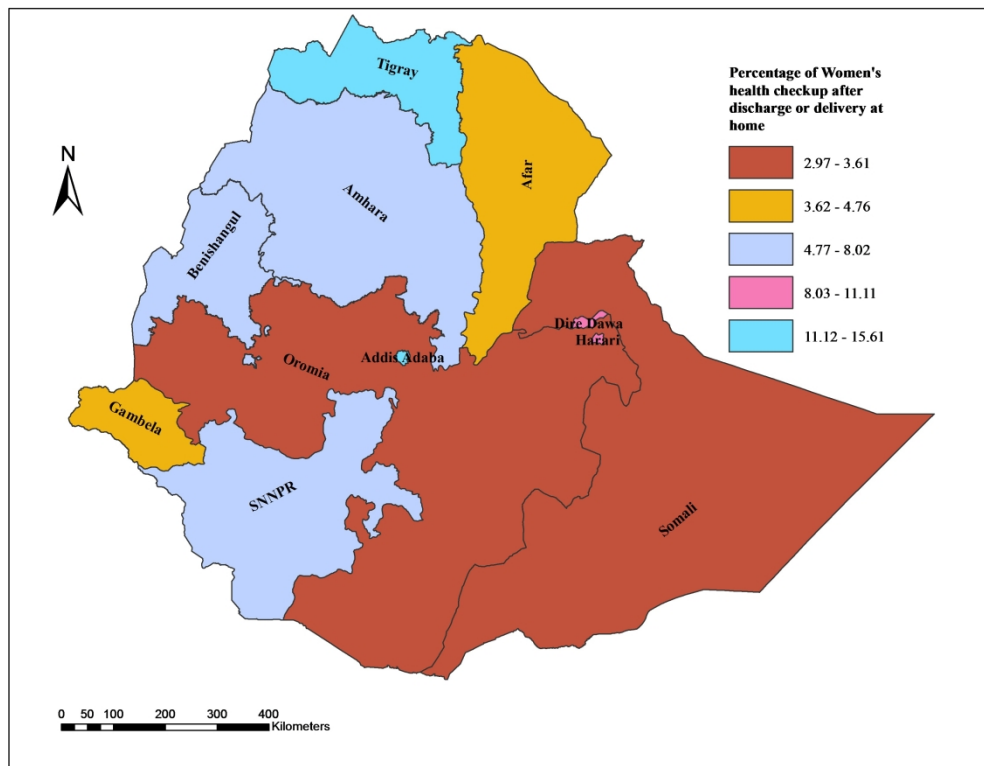
Given the z-score of 11.2181267202, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Spatial autocorrelation based on feature locations and attribute values using the Global Moran's I statistic
 267x254mm (300 x 300 DPI)



Spatial Clustering of Women's health checkup after discharge or delivery at home in Ethiopia, EDHS 2016

279x216mm (300 x 300 DPI)



Spatial distribution of Women's health checkup after discharge or delivery by percentages, Ethiopia, EDHS 2016

279x216mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	Spatial Patterns and Determinants of Postnatal Care Use in Ethiopian: A finding from Demographic and Health Survey, 2016	1
		<p>Objective: Postnatal cares (PNC) is one of the components of care to be provided to mothers and child. In Ethiopia, characterizing the spatial distribution of PNC utilization is essential to prioritize risk areas where PNC is needed and facilitate interventions. This study was aimed to explore geographical variations and identify the determinants of PNC utilization among women after delivery in Ethiopia.</p> <p>Methods: Ethiopian Demographic and Health Survey 2016 data were used and 7,193 women between 15 - 49 years of age were included in the analysis. The proportion of women who receive a health check-up after discharge and home delivery were recorded. Spatial cluster and autocorrelation analysis were done to explore the patterns of PNC utilization across the country. Multilevel logistic regression model was used to identify predictors of PNC utilization. Odds ratio with 95% confidence intervals (CI) were calculated to determine statistical significance. Mapping and spatial analysis were done using ArcGIS v10.1 software. All other data processing and analysis were done using Stata version 14 software.</p> <p>Results: The proportion of PNC utilization was 6.9 % (95% CI: 6.3%, 7.5%). There are spatial variations among regions in the country. Dire Dawa, Harari, and Jigjiga were with low utilization of PNC, whereas Tigray region utilized PNC highly at 99% confidence level. Factors including, mother with no education (AOR=0.55, 95%CL: 0.37, 0.84) and poorest wealth status (AOR=0.55, 95% CI: 0.39, 0.78) consistently predicted the lack of usage of PNC. In contrast, mothers in 35 – 49 years (AOR: 1.75, 95%CI: 1.01, 3.04) and women with at least one ANC visit (OR=2.37, 95% CI: 1.71, 3.29) were more likely to use PNC.</p> <p>Conclusion: Postnatal care utilization remains public health problem and has spatial variations at the regional level of the country. Uneducated women, young age, and poverty are barriers to PNC utilization. Educational status, wealth status, the age of mothers and ANC visits were predictors for PNC utilization. Hence, health promotion on ANC utilization and other predictors would be supreme important for better utilization of PNC.</p>	2

		Keywords: Postnatal Care, Demography and Health Survey, Women, Ethiopia	
Introduction			
Background/rationale	2	<p>In 2015, roughly 66% of the world's maternal mortality was found in Sub-Saharan Africa [1, 2]. A report in Ethiopia showed the presence of a large proportion of maternal and neonatal deaths despite the health system focusing on improving maternal health [3].</p> <p>PNC is used as an indicator of maternal health care in the post-partum period [4]. The World Health Organization (WHO) and Federal Ministry of Health (FMOH) of Ethiopia recommended that mothers must receive postnatal care at least once during the post-partum period [5-7]. Ethiopian health policies focus on maternal and child health care. As a result, maternal mortality rate decreased from 897 to 412 per 100,000 between 2000 and 2016 [6], while the antenatal care (ANC) is increased from 10.4% to 32% [8, 9]. However, PNC utilization remains very low in which only 13 to 26% of women received PNC in the last five years [10].</p> <p>Studies done in developing countries have looked into the factors associated with postnatal care utilization. Mother's Socio-demographic characteristics, including household wealth status, maternal education, maternal occupation, and residence were positively associated with PNC [11,12]. In addition, history of ANC, place of delivery and mother's knowledge of postpartum danger signs and symptoms are important predictors of postnatal care service utilization[13]. On the other hand, PNC service utilization depends on birth-related complication that can end maternal and neonatal death [14-16].</p> <p>The Ethiopian Ministry of Health has developed strategies to improve maternal and child health care utilization which is free of charge [17]. However, it is noted that the magnitude of maternal health services is heterogeneous geographically. Additionally, the extent of key barriers to PNC utilization are unexplored, which are cause maternal and neonatal death during the postnatal period. In Ethiopia, characterizing the spatial distribution of PNC utilization is essential to prioritize risk areas where PNC is needed and facilitate interventions. In another word, Understanding the levels and geographical variations of PNC utilization would help policymakers, planners, programmers and partners in the health sector to formulate appropriate strategies and interventions and provide quality reproductive health services.</p>	3 - 4
Objectives	3	Therefore, this study was aimed to explore geographical variations and identify the determinants of PNC utilization among women after delivery in Ethiopia	4
Methods			

Study design	4	We used Ethiopian Demography and Health Survey (EDHS) 2016 data which was a national representative cross-sectional survey	4
Setting	5	The study was conducted in Ethiopia, the country composed of nine Regional State and two city administrations. The country is the second most populous country in sub-Saharan Africa, with a population of over 100 million people and is a mainly rural country with only 17% of the population living in urban areas [18, 19]. Ethiopia has improvement in the coverage and utilization of the healthcare service after implementation of Health Sector Development Plan (HSDP) through decentralized in three-tier structure. Mainly, health centers provide preventative and basic curative services with referral system to the nearest high level of care [17]. Primary health cares are offered to all women free of charge including PNC in the country. In addition, the health centers composed a number of staffs such as health extension workers and health development army (HDA) to improve Universal Primary Health Care (PHC) coverage at the lowest level of administration.	4
Participants	6	The 2016 EDHS is the fourth Demographic and Health Survey conducted in the country. The study population was any women in childbearing age who gave birth in the last five years residing in the randomly selected enumeration areas (EAs). The study subjects were any women in childbearing age that gave birth in the last five years in Ethiopia.	4
Variables	7	The outcome variable of this study was women’s health check-up after discharge or delivery at home (PNC utilization). Based on WHO guideline, PNC utilization defined as women who received any postpartum check after discharge from health facility or delivery at home and extends up to six weeks (42 days) after birth prior to a survey [7, 21]. The response was dichotomized as “1” if the woman received at least one health check-up after discharge or delivery at home, otherwise assigned “0”. Independent variables were sociodemographic variables (age, educational level, occupation, religion, residence, region, and household wealth quintile), maternal reproductive health-related factors (place of delivery, antenatal care visit, sex of the child and health professions who checked maternal health after discharge or delivery at home.	5
Data sources/ measurement	8*	In Ethiopia, every five years, the Demographic and Health Survey program has collected data on national representative samples of all age group and key indicators including child health and maternal-related variables. Data collection took place from January 18, 2016, to June 27, 2016. EDHS datasets are available in the Measure DHS program website. After reviewing, we extracted 7,193 women data. The national shapefiles were used to maps the variations using ArcGIS 10.1.	5
Bias	9	After survey data extraction, further coding and analysis were done using STATA version 14 software.	5

		Sample weights were used to avoid geographical strata selection variability as well as for non-responses. The detailed explanation of the weighting procedure elsewhere in EDHS final report [22].	
Study size	10	The EDHS 2016 used a stratified two-stage cluster sampling design. The EAs were the primary sampling units and households were the second stage-sampling units. The survey included 15,683 women between ages 15 to 49 years old. A total of 7,193 women gave at least one birth in the last five years preceding the survey were included in the final analysis of this study.	6
Quantitative variables	11	Descriptive measures were used to summarize the overall characteristics of the study participants in the study area.	6
Statistical methods	12	<p>The spatial patterns of PNC were analysed using Geographical Information System (ArcGIS version 10.1) software. The application of GIS with spatial statistics clearly exhibited the spatial pattern of PNC. Spatial Autocorrelation analysis was performed to test whether the cases were distributed randomly over space and identified the pattern of PNC was clustered, dispersed, or random. Moran's I calculated I values as I=0 values was for random distribution, I<0 values for dispersed, and I>0 values for clustered [23].</p> <p>The cluster-outlier analysis (Anselin Local Moran's I) was employed to distinguish between a statistically significant ($p<0.01$) cluster of high values (High-High), cluster of low values (Low-Low), outlier in which a high value is surrounded primarily by low values (High-Low) and outlier in which a low value is surrounded primarily by high values (Low-High) [24]. A positive value for 'I' indicated that features with similar values, such type of feature surrounded the feature was part of a cluster. A negative value for 'I' indicated that features with dissimilar values surrounded the feature. Such a feature was an outlier [25].</p> <p>We applied spatial scan statistical analysis using Kuldorff's SaTScan version 9.4 software [26], to test for the presence of statistically significant spatial clusters of PNC. The spatial scan statistic uses a scanning window that moves across space [24]. The spatial patterns of PNC and its statistical significance was tested by Bernoulli probability model. With the assumption of Bernoulli probability function, we tested the null hypothesis whether there was no difference within the spatial window and outside the window. The default maximum spatial cluster size of <50% of the population was used, as an upper limit, which allowed both small and large clusters to be detected and ignored clusters that contained more than the maximum limit. For each potential cluster, a likelihood ratio test statistic was used to determine if the number of observed cases within the potential cluster was significantly higher than expected or not. The circle with the maximum likelihood ratio test statistic was defined as the most</p>	6-7

		likely (primary) cluster. The maximum observed value of the test statistic for each potential cluster was then compared with the overall distribution of maximum values. The primary and secondary clusters were identified and assigned p-values and ranked based on their likelihood ratio test, on the basis of 999 Monte Carlo replications [27, 28]. Multilevel binary logistic regression was used to calculate the measures between each of the independent variables (mother and household characteristics) and the likelihood of mothers using PNC services. The rationales for using a multilevel modelling were due to the multistage cluster sampling procedure, individual women were nested within clusters. Hence, the likelihood of women seeking maternal health services is likely to be correlated to the cluster members. Variables that had a relationship with PNC utilization ($p < 0.25$) were considered for the final model. Odds ratios with 95 % CI were used to declare statistical significance.	
Results			
Descriptive data	13*	A total of 7,193 women age 15-49 years who had at least one birth in the five years before the study period were included in the analysis. The majority 6621 (87.2%) of the respondents were rural residents. The mean age of the respondents was 29.26 years (SD ± 6.9). About 4791(63.1%) of the respondents had no education and about one-third of the respondents were in the poorest wealth quintile. The majority of the participants were from Oromia Regional State3130 (41.2%), followed by1633 (21.5 %) Amhara Regional State and SNNP 1601(21.1%).	7
Outcome data	14*	The proportion of postnatal health check-up after discharge or home delivery was found to be 6.9% (95% CI: 6.3%, 7.5%), with urban, 10.6% (95% CI: 9.1, 12.2), and rural 5.9% (95% CI: 5.3, 6.6)). PNC service utilization varied across the regions of the country with the highest proportion (15%) in Tigray regional state and lowest proportion (3%) in Gambella and Somali Regional State. The proportion of women’s health check-up after discharge or delivery at home in the women having antenatal care at least four visits was 10.5 % and, in the women, who delivered at a health facility, was 9.1 % (Table 1).	7
Main results	15	The global Moran’s index statistic was 0.084 (p-value < 0.0001), indicating the presence of a significant positive spatial autocorrelation in women’s health check-up after discharge or delivery at home in Ethiopia (Figure 1). The spatial clustering is highly pronounced at a distance of 225.2 KMs with a corresponding Z score of 12.592741 (P-value <0.0001) (Figure 2). According to LISA analysis, high clusters were observed in the major part of Tigray region (Central, eastern, western and southern Tigray) at 99% confidence level, but at 95%CI it was found at Addis Ababa town, western Tigray, North Shewa, south Shewa and East Gojjam zone of Amhara regional state, Arsis zone of Oromia region and Gurage	8-9

		<p>zone of SNNP region. In contrast, low significant clustering of women's health check-up after discharge or delivery at home were major parts of Gambella region, Harari, jigjig and Eastern Haragie (Figure 3). The SaTScan spatial analysis was identified three clusters. The primary clusters (LLR = 20.72, $p < 0.0001$) were detected in Southeastern Ethiopia. A second cluster (LLR = 19.36, $P < 0.0001$) were detected in east of Ethiopia. The final cluster (LLR = 10.91, $P = 0.048$), were in Northern Ethiopia (Table2, Figure 4).</p> <p>Despite all observations were low, relatively the highest percentage of women's health check-up after discharge or delivery at home was observed in Tigray region, 15.6% and Addis Ababa, 13.1%%, whereas the lowest observation in Somali (3.0%), Oromia (3.6%) and Afar (4.2%) (Figure 5).</p> <p>Factors associated with PNC utilization</p> <p>Demographic and socio-economic variables were selected using Enter methods at 0.25 significance level. In the final model, maternal education, wealth index and ANC visit were identified as associated factors with women's health check-up after deliver.</p> <p>Level of education showed strong statistical association with postnatal care service utilization. Mothers who have no education were about 33% times (AOR=0.55, 95%CL: 0.37, 0.84) less likely to utilize postnatal care service than educated (above Secondary) women. Similarly, the odds of poorest decreased the chance of utilizing postnatal care service by about one-third fold (AOR=0.55, 95% CI: 0.39, 0.78) less likely than richest women.</p> <p>Age of women has also been an important predictor of postnatal care service utilization. Mothers who age group in 35 – 49 years were about 1.75 times (AOR: 1.75, 95%CI: 1.01, 3.04) more likely to utilize postnatal care service utilization than younger than 19 years. Postnatal care service utilization also increased with increasing ANC visits of mothers. Women who had one to three ANC visit (OR=2.37, 95% CI: 1.71, 3.29) were more likely to receive health check-up after delivery than no Antenatal Care. Moreover, Mothers who had fourth ANC visit were about 3-fold (AOR: 3.43, 95%CI: 2.47, 4.76) more likely to utilize postnatal care service than those who had no any type of ANC visits (Table 3).</p>	
Discussion			
Key results	16	<p>Postnatal care utilization among women in Ethiopia was low and varied across socio-demographic characteristics. Regional disparity (Spatial pattern) was observed in postnatal care utilization among Ethiopian women. Higher educational level, better wealth index, antenatal care at least one visit and place of delivery were significant predictors of postnatal care utilization among women in Ethiopia. Thus, there is a need to devise such strategies, ensuring availability, accessibility and affordability of</p>	11

		<p>PNC for mother and newborn considering geographical difference. Emphasis should be given on designing public health interventions to educate and raise awareness among mothers and families regarding importance of PNC, timing for PNC check-up.</p>	
<p>Limitations</p>	<p>17</p>	<p>The study has addressed PNC utilization and spatial disparity; however, it has the following limitations. First, the analysis is designed to identify predictors of PNC and spatial patterns, but it does not point directly to explanations for these outcomes. This is a less helpful for explaining causality. Secondly, the study was represented the experiences of the participants in the 5 years that followed the study period. This might lead to recall biases, which in turn the findings may not be generalizable. Finally, there may be unmeasured variables that predict the outcomes. One example is health facility related factors like quality of services. Further research should consider the potentially important predictors.</p>	<p>10</p>
<p>Interpretation</p>	<p>18</p>	<p>This study was investigated factors and spatial variations of postnatal care utilizations among Ethiopian women using the 2016 Ethiopian DHS data.</p> <p>The study showed that Ethiopia continued to have low proportion of postnatal care (PNC) utilization. The finding was smaller than 2011 EDHS [8, 12] that indicated maternal and child health remains poor. This may be attributed to the samples difference and could be improvement in quality of data to date. It was found to below with studies done in Amhara region, Ethiopia [14, 29] and southern Ethiopia [30]. The difference might be due to our study include rural areas and study characteristics. This low result may be attributed by Programmatic problem impact on a woman's making a PNC visit and low exposure to the mass media. In comparison with other countries, Ethiopia is behind in postnatal care (PNC) utilization; including Kenya (47%)[31, 32], Nigeria (29%)[33], Nepal (40.9%)[11] and Tanzania (10.5%)[34]. This variation can also be attributed due to the time difference and could be improvement in health care utilization conducted in Kenya unlike to our study. The postnatal care (PNC) utilization is varies geographically in Ethiopia. Specifically, Tigray region and Addis Ababa city have hotspot areas. The study found that PNC was considerably varied in demographic characteristics; for example, 57% women who delivered at health facility, Orthodox religion (12.9%) and Addis Ababa residents (51.6%) were more user and PNC utilization was directly increased as level of maternal education and wealth index. This Study consistent studies conducted in Ghana and India found some geographic variations in socioeconomic inequalities [35, 36].</p> <p>This study identified several factors that indicate strong influence on the utilization of PNC services: age of mother, mother's level of education, household wealth quintile and ANC visit. Those women with no education less likely to use postnatal care as compared to women who educated more than secondary school. This finding is consistent with Nigeria [37], Kenya [32] and Nepal [11], Ethiopia[12, 14, 30, 38,</p>	<p>9-10</p>

		<p>39] and India [36]. This could be explained by the fact that education has a valuable input in enhancing female autonomy and help women develop greater confidence and capability to make decisions about their own health. Thus, literate women seek out higher quality health services and have greater ability to use health care inputs that offer better health outcomes.</p> <p>Similarly, Women in poorest wealth quintile level were less likely to use PNC as compared to richest wealth quintile in attending at least one postnatal care visit. This study is similar with evidence from study conducted in Ethiopia [12]. Our finding is also in line with others studies: Pakistan [40], Nepal and Rwanda[11, 41]. Richest Women’s may get more information of Children’s Health from mass media and health professionals privately subsequently; families may arrange institutional health services.</p> <p>Postnatal care utilization was positively associated with antenatal care service. That is Mothers who attended ANC services more frequently were more likely to receive PNC services compared to those who had attended less than one ANC services. This finding is similar with study in Nepal[11], India[36]Tanzania [34] and Kenya [32].The possible reason may be ANC users perceived that health system has provided quality care based on previous experiences. Furthermore, this could be due to variations of socio-demographic, cultural differences, which may lead to health service related to pregnancies.</p> <p>In this study, we found that mother’s older age at delivery was positively associated with PNC use. Our finding is contrast with study done in Rwanda[41]. The main reason is differences in cultural. In Ethiopia, older women were more involved in their own health care decision-making and respected than younger women. This may be reinforced that women who are empowered to make health care choices previous experiences and then older women more likely to use PNC services.</p>	
Generalisability	19	This study was a national representative in Ethiopia.	
Other information			
Funding	20	No funds received for the present study	

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

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2 **Spatial Patterns and Determinants of Postnatal Care Use in Ethiopia: Findings from the**
3 **2016 Demographic and Health Survey**
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Abstract

Objective: Postnatal cares (PNC) is essential for preventing maternal and newborn deaths, however it still remains less well recognized in developing countries. This study was aimed to explore geographical patterns and identify the determinants of PNC utilization among age 15-49 women in Ethiopia.

Methods: A secondary data analysis was conducted using the 2016 Ethiopia demographic and health survey data. A total of 7, 193 women were included in this analysis. We employed spatial scan statistics to detect spatial inequalities of PNC utilization among women. Multilevel binary logistic regression model was fitted to identify factors associated with women's PNC.

Results: The prevalence of PNC utilization among women was 6.9 % (95% CI: 6.3%, 7.5%). The SaTScan spatial analysis identified three most likely clusters with low rates of postnatal care use included Southwestern Ethiopia (LLR = 18.07, $p < 0.0001$), Southeast Ethiopia (LLR=14.29, $P < 0.001$) and Eastern Ethiopia (LLR=10.18, $P=0.024$). Women with no education (AOR=0.55, 95%CL: 0.37, 0.84) and poorest wealth quantile (AOR=0.55, 95% CI: 0.39, 0.78) were less likely to use PNC, while women with age 35-49 years (AOR: 1.75, 95%CI: 1.01, 3.04), and antenatal care at least four visits (AOR=2.37, 95% CI: 1.71, 3.29) were more likely to use PNC.

Conclusion: Postnatal care utilization remains a public health problem and has spatial variations at the regional level of the country. Low prevalence of PNC was detected in the Ethio-Somali, Oromia, Gambella and SNNPR Regions. Women with low educational status, older age, being in poorest wealth quantile and history of ANC visit are significantly associated with postnatal care utilization. Hence, maternal health programs targeting the strengthening of maternal health services should place, special emphasis could be given on health promotions with continuum of care during pregnancy.

Keywords: Women, postnatal care, spatial, multilevel Demography and Health Survey, Ethiopia

Strengths and limitations of this study

- The study used a recent national community-based survey. Thus, it is potential to inform policy and interventions at subnational and regional levels.
- As a cross-sectional survey, we are unable to draw causal conclusions. However, our method used multilevel modelling, which took into account the effect of clustering to better estimate the level of association of the study factors with the outcome
- The study was based on the self-report of respondents and provided no validation of obtained information with any objective source. This might lead to recall bias, which in turn the findings may not be generalizable.
- As a secondary data analysis, some important variables were not available for analysis such as cultural beliefs, when women are allowed to leave the house in the postpartum period, roles of husbands in maternal health decision-making, and perceptions about whether pregnancy is a medical issue warranting clinical visits.
- In this Study, the geographic coordinates of EAs are displaced up to 5km to prevent identification of the respondents or the community. This could affect the cluster effect in the spatial analysis. So that those should be interpreted with cautions.

Background

In 2015, roughly 66% of the world's maternal mortality were found in Sub-Saharan Africa [1, 2]. A report in Ethiopia showed the presence of a large proportion of maternal and neonatal deaths despite the health system is focusing on improving maternal health [3, 4].

PNC is used as an indicator of maternal health care in the post-partum period in Ethiopia [5]. According to World Health Organization (WHO), postnatal period is critical for both mother and baby that all women and newborns receive at least three postnatal contacts following delivery [6-8]. Since, postnatal cares is an opportunity for providers to facilitate healthy breastfeeding practices, screen for postpartum depression, monitor the newborn's growth and overall health status, treat childbirth-related complications, counsel women about their family planning options and refer the mother and baby for specialized care if necessary, among other services. In Ethiopia, maternal mortality rate decreased from 897 to 412 per 100,000 between 2000 and 2016 [7], while the antenatal care (ANC) is increased from 10.4% to 32% [9, 10]. However, PNC utilization remains very low in which only 13 to 26% of women received PNC [11].

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2 Studies done in developing countries have looked into the factors associated with postnatal care
3 utilization. Mother's socio-demographic characteristics, including household wealth status,
4 maternal education, maternal occupation, and residence were positively associated with PNC
5 [12, 13]. In addition, a history of ANC, place of delivery and mother's knowledge of postpartum
6 danger signs and symptoms are important predictors of postnatal care service utilization [14]. On
7 the other hand, the PNC service utilization depends on birth-related complication that can end
8 maternal and neonatal death [15-17].

9
10 Increasingly, efforts have made to improve health coverage and expenditures expanded
11 universally; however, important maternal health inequities are concealed in smaller administrative
12 areas. Currently, the Ethiopia health care strategy is focused on primary health care units
13 included health centers, health stations, health posts and private clinics. However, it is noted that
14 the magnitude of maternal health services is heterogeneous geographically. Additionally, the
15 extent of key barriers to PNC utilization is unexplored, which are caused maternal and neonatal
16 death during the postnatal period.

17
18 Spatial study is important to identifying high-risk geographic areas within a community, as well
19 as it helps to understand what could be driving disparities in low maternal health services and
20 suggest community-based interventions in these areas. Thus, understanding the spatial
21 epidemiology of postnatal care is crucial for evidence-based decision making to improve maternal
22 health services. However, studies on the spatial epidemiology of women's postnatal care are
23 limited and the driving factors are poorly understood in Ethiopia. Hence, this study aimed to
24 contribute evidences on the geographical pattern of postnatal care and associated factors among
25 women.

26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 **Methods**

42 43 44 **Data Source**

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46 A secondary data analysis of the 2016 Ethiopia demographic and health survey (2016 EDHS)
47 data was conducted. Ethiopia is second most populous country in Africa, located in the horn of
48 Africa. Administratively, Ethiopia is subdivided into 11 geographical regions, each region is sub-
49 divided into zones, and districts. The districts in-further are sub-divided into kebeles (the smallest
50 administrative units). Based on the 2007 population and housing census of Ethiopia, each kebele
51 administrative was subdivided again into enumeration areas (EAs). These enumeration areas
52 were used as a primary sampling unit for the fourth EDHS [18, 19]. In Ethiopia, health care service
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2 has been improved after implementation of the Health Sector Development Plan (HSDP) through
3 decentralized in three-tier structure. Mainly, health centers provide preventative and basic
4 curative services with the referral system to the nearest high level of care [4]. Primary health
5 cares are offered to all women free of charge, including PNC throughout in the country. In
6 addition, the health centers composed a number of staffs such as health extension workers and
7 health development army (HDA) to improve Universal Primary Health Care (PHC) coverage at
8 the lowest level of administration.

9
10 In recent years, DHS is a nationally representative survey designed to provide population and
11 health indicators at the national (urban and rural) and regional levels. As a result, the 2016 EDHS
12 was conducted by the Central Statistical Agency (CSA) with funding support from the government
13 of Ethiopia, the United States Agency for International Development (USAID), the government of
14 the Netherlands, the Global Fund, Irish Aid, the World Bank, the United Nations Population Fund
15 (UNFPA), the United Nations Children's Fund (UNICEF), and UN Women. ICF International
16 provided technical support [20]. The data used for this study were drawn from 2016 EDHS. The
17 surveys used a stratified two-stage cluster sampling, which is conducted every five year and the
18 2016 EDHS is the fourth survey in Ethiopia. In the first stage, a total of 645 EAs (202 in urban
19 areas and 443 in rural areas) were selected with probability proportional to EAs size (PPS) from
20 the complete list of 84,915 EAs created for the 2007 PHC sampling frame. In the second stage
21 of selection, a fixed number of 28 households per cluster were selected with an equal probability
22 systematic selection from the newly created household listing.

23
24 The source population of this study was any women in child bearing age who gave birth in the
25 last five years preceding the survey in Ethiopia and the study population were any women in child
26 bearing age that gave birth in the last five years preceding the survey in the selected enumeration
27 areas. In this survey, a total of 16,650 households were successfully interviewed, yielding a
28 response rate of 98% and a total of 7,193 women in child bearing age who gave birth in the last
29 five years before the survey were included in this analysis. The 2016 EDHS data sets were
30 downloaded in SPSS format with permission from the Measure DHS website
31 (<http://www.dhsprogram.com>).

32
33 The outcome variable of this study is postnatal care utilization status among reproductive age
34 women. In this study, PNC utilization is defined as women's health checkup after discharge from
35 health facility or home delivery within the first six weeks (42 days) after delivery [8, 21]. The
36 survey collected this data from mother's verbal reports whether a woman had received PNC after
37 discharge from health facility or delivery at home. We categorized this variable into "Yes" (when
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1 woman had received PNC at health facility) and otherwise “No”. The independent variables of
2 this study such as socio-demographic variables (age, educational level, occupation, religion,
3 residence, region, and household wealth quintile), and maternal reproductive health-related
4 factors (place of delivery, number of antenatal care visits, sex of the child) were extracted
5 accordingly. The choice of explanatory variables was guided by the literatures.
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10 11 12 **Data management and statistical analysis**

13 After data extraction, further coding and analysis was done using STATA version 14 software.
14 Sample weights were used to avoid geographical strata selection variability as well as for non-
15 responses. The detailed explanation of the weighting procedure elsewhere in the EDHS final
16 report [22].
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18 Descriptive measures were used to summarize the overall characteristics of the study participants
19 in the study area. Multilevel binary logistic regression analysis was used to calculate the
20 measures between each of the independent variables (mother and household characteristics)
21 and the likelihood of mothers using PNC services. The rationales for using a multilevel modeling
22 were due to the multistage cluster sampling procedure, individual women were nested within
23 clusters. We used the region as cluster variables. Hence, the likelihood of women seeking
24 maternal health services is likely to be correlated to the cluster members. Variables that had a
25 relationship with PNC utilization ($p < 0.25$) were considered for the final model. Odds ratios with
26 95 % CI were used to declare statistical significance.
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36 **Spatial analysis**

37 The global spatial autocorrelation was assessed using the Global Moran's I statistic (Moran's I)
38 to evaluate whether the pattern is clustered, dispersed, or random across the study area using
39 ArcGIS version 10.3 [23]. A positive value for Moran's Index indicates a clustered pattern of PNC,
40 while a negative value for Moran's Index indicates a dispersed pattern [23, 24].
41

42 In the presence of positive global spatial autocorrelation, we used purely spatial scan statistics
43 using Bernoulli probability model to detect local clusters with low or high rate of PNC [25].
44 SaTScan 9.4 software was used for the local cluster detection analysis [25, 26]. It uses a circular
45 window which moves systematically throughout the study area to identify significant SaTScan
46 clustering of women who received PNC. The default maximum spatial cluster size of <50% of the
47 population was used as an upper limit, which allowed both small and large clusters to be detected
48 and ignored clusters that contained more than the maximum limit. For each potential cluster, a
49 log likelihood ratio test statistic was used to determine if the number of observed cases within the
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2 potential cluster was significantly higher than expected or not. The circle with the maximum
3 likelihood ratio test statistic was defined as the most likely (primary) cluster, then compared with
4 the overall distribution of maximum values. The primary and secondary clusters were identified
5 and assigned p-values and ranked based on their likelihood ratio test, on the basis of 999 Monte
6 Carlo replications [27, 28].
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10 11 12 **Patient and public involvement statement (PPI)**

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14 Patients and the public were not involved in this secondary data analysis. However, for the
15 original project from which data was obtained, PPI participation was essential. Since biomarkers
16 such as anthropometry, anaemia, and HIV testing were collected in all households [22].
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20 21 **Results**

22 23 **Socio-demographic characteristics of the study participants**

24
25 A total of 7,193 women age 15-49 years who had at least one birth in the five years before the
26 study were included in the analysis. The majority 6621 (87.2%) of the respondents were rural
27 residents. The mean age of the respondents was 29.3 years (SD \pm 6.9). About 4791 (63.1%) of
28 the respondents had no education and about one-third of the respondents were in the poorest
29 wealth quintile. The majority of the participants were from Oromia Regional State 3130 (41.2%)
30 followed by 1633 (21.5 %) Amhara Regional State and SNNP 1601 (21.1%) (**Table 1**).
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33 34 **Prevalence of postnatal care**

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36 The prevalence of postnatal care utilization among women was 6.9% (95% CI: 6.3%, 7.5%) with
37 10.6% (95% CI: 9.1, 12.2) in urban and 5.9% (95% CI: 5.3, 6.6) in rural areas. PNC utilization is
38 varied across the regions of the country with relatively highest prevalence (15%) in Tigray Region,
39 and lowest (3%) in Ethio-Somali Region. The prevalence of postnatal care was 10.5 % in women
40 with at least four visits of antenatal care, and 9.1 % in women who delivered in a health facility
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47 (**Table 1**).

48 49 **Spatial distribution of PNC Utilization**

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51 The global spatial autocorrelation analysis revealed a clustering pattern of women's postnatal
52 care utilization across the study areas (Global Moran's I = 0.084, p-value < 0.001) (**Figure 1**).

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54 The SaTScan spatial analysis detected a total of three statistically significant SaTScan
55 clusters areas with low postnatal care utilization. The most likely primary SaTScan cluster of
56 areas with low PNC were detected in the Southeastern Ethiopia (LLR= 20.72, p < 0.0001), and
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2 secondary cluster in Eastern Ethiopia (LLR = 19.36, $P < 0.0001$). The third most likely SaTScan
3 cluster (LLR = 10.91, $P = 0.048$) was detected in the Northern part of Ethiopia (**Table 2, Figure**
4 **2**). Despite all observations were low, relatively the highest cluster of PNC utilization was
5 observed in Tigray Region (**Figure 3**).
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9 **Factors associated with PNC utilization**

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11 Demographic and socioeconomic variables were selected using enter methods at 0.25
12 significance level. In the final model maternal education, wealth index and ANC visit were
13 identified as associated factors with women's PNC utilization after delivery.
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17 Level of education showed strong statistical association with postnatal care service utilization.
18 Mothers who have no education were about 45% times (AOR=0.55, 95%CI: 0.37, 0.84) less
19 likely to utilize postnatal care service than educated (above Secondary) women. Similarly, women
20 belong to poorest wealth quintiles were 45% decreased the chance of utilizing postnatal care
21 service (AOR=0.55, 95% CI: 0.39, 0.78) than richest women.
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25 The age of women has also been an important predictor of postnatal care service utilization.
26 Mothers who age group in 35 – 49 years were about 1.75 times (AOR: 1.75, 95%CI: 1.01, 3.04)
27 more likely to utilize postnatal care service utilization than younger than 19 years. Postnatal care
28 service utilization also increased with increasing ANC visits of mothers. Women who had one to
29 three ANC visit (OR=2.37, 95% CI: 1.71, 3.29) were 2.37 times more likely to receive health
30 checkup after delivery than no Antenatal Care. Moreover, Mothers who had a fourth ANC visit
31 were about 3-fold (AOR: 3.43, 95%CI: 2.47, 4.76) more likely to utilize postnatal care service than
32 those who had no any type of ANC visits (**Table 3**).
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Discussion

In this study, the prevalence of women's postnatal care utilization was found to be 6.9% in Ethiopia with spatial heterogeneity. The spatial scan statistics detected a total of three statistically significant SaTScan clusters of areas with low prevalence of PNC.

The study showed that Ethiopia continued to have a low proportion of postnatal care utilization. The finding was smaller than 2011 EDHS [9, 13] that indicated maternal and child health remains poor. This may be attributed to the samples difference and could be an improvement in the quality of data to date. It was found to be below with studies done in Amhara region, Ethiopia [15, 29] and southern Ethiopia [30]. The difference might be due to our study include rural areas and sociocultural characteristic variations. This low result may be attributed by programmatic problem impact on a woman's making a PNC visit and low exposure to the mass media. As compared to the study findings from low income and middle income countries such as Kenya (47%) [31, 32], Nigeria (29%) [33], Nepal (40.9%) [12] and Tanzania (10.5%) [34], the postnatal care utilization was low in Ethiopia. This could be due to the differences in health service accessibility, study time and quality of care across the countries.

A clustered pattern of areas with low and high rate of PNC was observed in general in which clusters of areas with high rates of PNC were detected in Addis Ababa city and Tigray Region, whereas low PNC rates were detected in eastern, southeastern and northern part of Ethiopia. This clustered pattern could be attributed to differences in health service accessibility, and quality of health care, suggest that local administration may be operating different systems of primary health care services. In addition, it could be as result of socio-cultural differences during postnatal period activities. This finding is supported by study findings conducted in Ghana and India found in which geographic variations was observed [35, 36].

In the multilevel logistic regression, maternal age, educational status, household wealth quintile, and ANC visit were identified as predictors of PNC. Women with no education were less likely to use postnatal care as compared to women who educated more than secondary school. This finding is consistent with studies in Ethiopia [13, 15, 30, 37, 38] and other low-income countries, such as Nigeria [39], Kenya [32], Nepal [12], and India [36]. This could be explained by the fact that education has a valuable input in enhancing female autonomy as well as help them to develop greater confidence and capability to make decisions about their own health. Thus, literate

1
2 women seek out higher quality health services and have greater ability to use health care inputs
3 that offer better health outcomes.
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6 Similarly, Women belong in the poorest wealth quintile level were less likely to use PNC as
7 compared to richest wealth quintile in attending at least one postnatal care visit. This study is
8 similar to evidence from a study conducted in Ethiopia [13]. Our finding is also in line with others
9 studies: Pakistan [40], Nepal and Rwanda [12, 41]. Richest Women's may get more information
10 about children's health from mass media and health professionals privately subsequently;
11 families may arrange institutional health services.
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14
15 Postnatal care utilization was positively associated with antenatal care service. Women who had
16 history of ANC visit were more likely to receive PNC service as compared to their counter parts.
17 This finding is supported by the study findings in Nepal [12], India [36], Tanzania [34] and Kenya
18 [32]. The possible reasons for the positive effects of ANC on PNC is that ANC offers women an
19 entry point to the health care system as well as providing counselling and awareness of the
20 benefits of PNC. Additionally, if the ANC experience was positive, then women are more ready
21 to attend a PNC visit. Furthermore, this could be due to variations of socio-demographic, cultural
22 differences, which may lead to seek health service related to pregnancies.
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26 In this study, we found that mother's older age at delivery was positively associated with PNC
27 use. Our finding contrasts with a study done in Rwanda [41]. The main reason is differences in
28 culture. In Ethiopia, adult women were more involved in their own health care decision-making
29 and respected than younger women. This may be reinforced that women who are empowered to
30 make health care choices base on previous experiences of any maternal health care services.
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34 The main strength of this study was the use of a nationally representative data with large sample
35 of the community-based study. The other strength, we used spatial and advanced statistical
36 approach to accommodate the hierarchy nature of data. However, this study is not free from
37 limitation and should be mentioned. Due to the retrospective nature of the data, and the maternal
38 verbal reports for PNC, recall bias might have been introduced. The others limitation was that
39 DHS did not provide information about accessibility (i.e., distance to a health facility) or the quality
40 of healthcare providers which might influence the use of PNC among reproductive age women.
41 Lastly, the geographic coordinates of EAs are displaced up to 5km to prevent identification of the
42 respondents or the community. This could affect the cluster effect in the spatial analysis. So that
43 those should be interpreted with cautions.
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Conclusion: This study showed that postnatal care utilization has variations in geographic areas of Ethiopia. Local clusters of areas with low prevalence PNC among women were detected in the Ethio-Somali, Oromia, Gambella, and SNNPR Regions. Women with low educational status, older age, poorest wealth quantile, and history of ANC visit are significantly associated with postnatal care utilization. Hence, the government of Ethiopia and other stakeholders could tailor effective maternal health programmers to mitigate the gap from geographic areas inequalities identified in this study. It is also better to promote health education, and antenatal care visit with continuum of care. Further research is recommended to investigate why regional disparity is existing in Ethiopia.

List of abbreviations

ANC	Antenatal Care
CI	Confidence Interval
CSA	Central Statistical Agency
DHS	Demographic and Health Survey
EA	Enumeration Area
EDHS	Ethiopia Demographic and Health Survey
FMOH	Federal Ministry of Health
OR	Odds Ratio
PNC	Post Natal Care
SD	Standard Deviation
SNNP	Southern Nations Nationalities and Peoples
SPSS	Statistical Package for Social Science
WHO	World Health Organization

Declarations

Ethics and consents

Permission consent was obtained to access the 2016 Ethiopia Demographic and Health Survey from Measure DHS International Program, which authorized the data sets. All data were extracted without having any personal identifying information that could be linked to particular individuals,

1 communities, or study participants. As the study was secondary data analysis, the research ethics
2 was waived. Confidentiality of data maintained anonymously.
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8 **Consent for publication**

9

10 Not applicable.
11

12 **Availability of data and materials**

13 All relevant data are available within the manuscript. However, the minimal data underlying all
14 the findings in the manuscript will be available upon request. Moreover, this study was based on
15 an analysis of existing public domain survey data sets that is freely available online in the
16 Measure DHS Program repository, (<http://www.dhsprogram.com>) to all registered users.
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23 **Competing interests**

24 The authors declare that they have no competing interests.
25
26
27

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29 The authors had no funding support for this study.
30
31

32 **Authors' contributions**

33 TT, YW, AT and DK conceptualized and designed the study. MM, MF, TT, YW, AT and DK carried
34 out the literature review, data extraction and analysis. MM drafted the manuscript. KA, TA, AA
35 and MF participate in data analysis and reviewed the manuscript. All authors read and approved
36 the final version of the manuscript.
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Table 1: Postnatal care use by background characteristics among women age 15-49 who had given birth in the five years preceding the survey, EDHS 2016

Background characteristics	Percentage of PNC use	Number of women PNC use		
		Weighted	Unweighted	
Age (in years)	15 - 19	4.4	338	358
	20 - 34	6.6	5291	5041
	35 - 49	5.8	1960	1794
Religion	Orthodox Christian	9.4	2882	2369
	Muslim	4.0	2824	3324
	Protestant	5.5	1652	1338
	Others*	0.9	232	162
Residence	Urban	12.1	969	1512
	Rural	5.5	6621	5681
Region	Tigray	15.6	538	772
	Afar	4.2	71	647
	Amhara	8.0	1633	764
	Oromia	3.6	3130	1031
	Somali	3.0	269	806
	Benishangul	7.4	81	576
	SNNPR	6.3	1601	893
	Gambella	4.8	21	534
	Harari	11.1	18	411
	Addis Ababa	13.6	198	375
Dire Dawa	9.1	33	384	
Maternal Education	No education	4.8	4791	4359
	Primary	7.7	2150	1942
	Secondary	11.9	420	577
	Higher	13.5	229	315
Husband/partner's education level	No education	4.9	3345	3136
	Primary	6.6	2731	2160
	Secondary	9.3	612	745
	Higher	10.9	376	569
	Don't know	9.3	43	52
Wealth index	Poorest	3.1	1652	2428
	Poorer	3.9	1654	1179
	Middle	5.9	1588	1028
	Richer	8.3	1426	917
	Richest	11.8	1269	1641
ANC Visit	No ANC Visit	2.4	2818	2481
	ANC one to three visits	6.6	2342	2092
	ANC at least four visits	10.5	2429	2620
Place of Delivery	Health facility	9.1	2408	2699
	Other than Health facility	5.0	5181	4494
Sex of child	Male	5.8	3941	3718
	Female	6.8	3649	3475
Child Wanted	Wanted then	5.9	5573	5741
	Wanted later	7.9	1321	991

	Wanted no more	6.0	695	461
Birth Order	1	7.1	1434	1470
	2 - 3	7.2	2281	2217
	4 - 5	6.0	1752	1638
	6+	5.0	2122	1868

*Catholic, Traditional and other unclassified

Table 2: The most likely SaTScan clusters of areas with low prevalence of postnatal care among women in Ethiopia, 2016

Cluster	Region (Zones)	Number of clusters	Radius (km)	LLR*	p-value
1	Oromiya Region (Kelem Wollega, West Wolega, East Wollega, Kemash and Jimma), Gambella Region (Nuer and Agnuak), and SNNPR Region (Sheka, Majang, Keffa, Benchi Maji, Konta, Dawro, South Omo and Basketo Gamo goffa)	73	225.2	18.07	< 0.001
2	Oromiya region (Borena, Guji, Bale, West Arsi, West and East Hararge), Ethio-Somali Region (Doolo, Korah, Jarar and Nogab), and SNNPR (Gedio and Sidama)	39	467.6	14.19	< 0.001
3	Oromiya Region (Bale and Guji), and Ethio-Somali Region (Liben, Afder and Shabelle)	14	282.34	10.28	0.024

*Log likelihood ratio

Table 3: Factors associated with PNC utilization among Women giving birth in the last 5 years preceding the survey in Ethiopia, 2016.

	Variables	PNC use		COR (95% CI)	AOR (95% CI)
		Yes	No		
Maternal Education	Above Secondary	45	270	1.00	1.00
	No education	226	4,133	0.39(0.27, 0.56)	0.55(0.37, 0.84)
	Primary	158	1,784	0.57(0.39, 0.83)	0.69(0.46, 1.01)
	Secondary	67	510	0.81(0.54, 1.23)	0.87(0.57, 1.315)
Age (in years)	15 - 19	16	342	1.00	1.00
	20 - 34	351	4,690	1.47(0.88, 2.47)	1.47(0.87, 2.48)
	35 - 49	129	1,665	1.46(0.85, 2.51)	1.75(1.01, 3.04)
Religion	Orthodox Christian	246	2,123	1.00	1.00
	Muslim	179	3,145	0.83(0.63, 1.11)	
	Protestant	69	1,269	0.78(0.54, 1.14)	
	Others*	2	160	0.18(0.04, 0.75)	
Residence	Urban	160	1,352	1.00	
	Rural	336	5,345	0.60(0.47, 0.76)	
Wealth Index	Richest	180	1,461	1.00	1.00
	Poorest	87	2,341	0.39(0.28, 0.55)	0.55(0.39, 0.78)
	Poorer	74	1,105	0.64(0.45, 0.89)	0.75(0.54, 1.056)
	Middle	75	953	0.77(0.55, 1.07)	0.85(0.61, 1.19)
	Richer	80	837	1.06(0.78, 1.45)	0.94(0.63, 1.407)
ANC visit	No antenatal care	58	2,423	1.00	1.00
	ANC one to three visits	141	1,951	2.58(1.88, 3.54)	2.37(1.71, 3.29)
	ANC at four visits	297	2,323	4.09(3.01, 5.55)	3.43(2.47, 4.76)
Sex of child	Male	233	3,485	1.00	1.00
	Female	263	3,212	1.20(1.00, 1.45)	
Place of delivery	Health facility	266	2,433	1.00	
	Other than health facility	230	4,264	0.67(0.54, 0.82)	

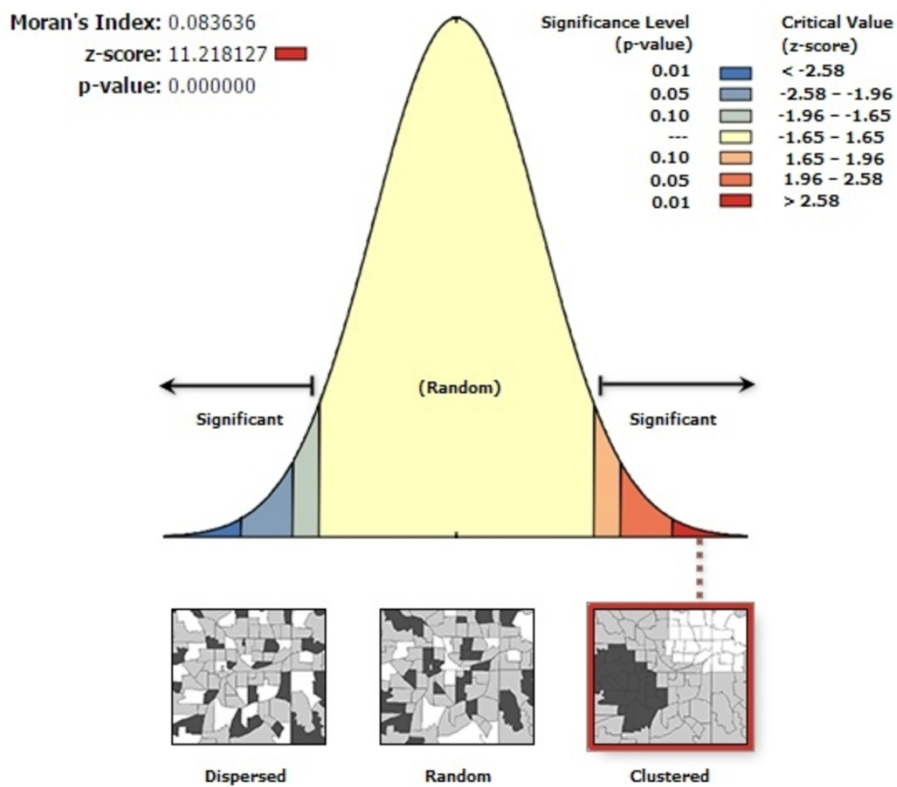
*Catholic, Traditional and other unclassified

Figure legends

Figure 1: Spatial autocorrelation based on feature locations and attribute values using the Global Moran's I statistic.

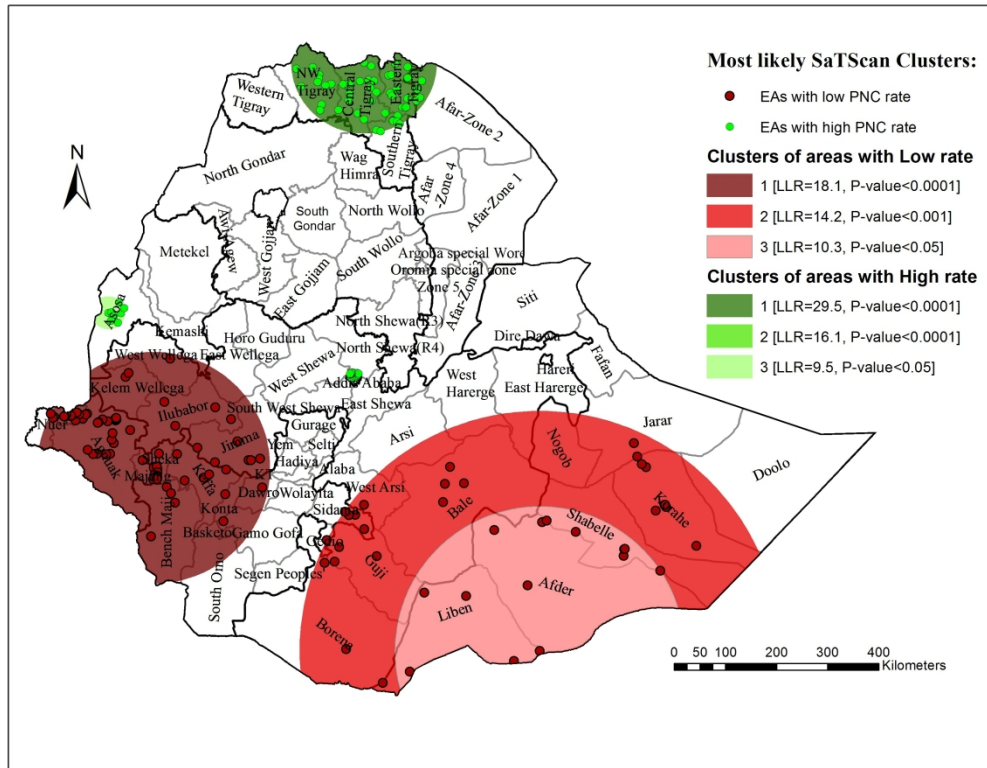
Figure 2: Spatial clustering of women's postnatal care in Ethiopia, 2016

Figure 3: Percentage distribution of women's postnatal care by Region in Ethiopia, 2016



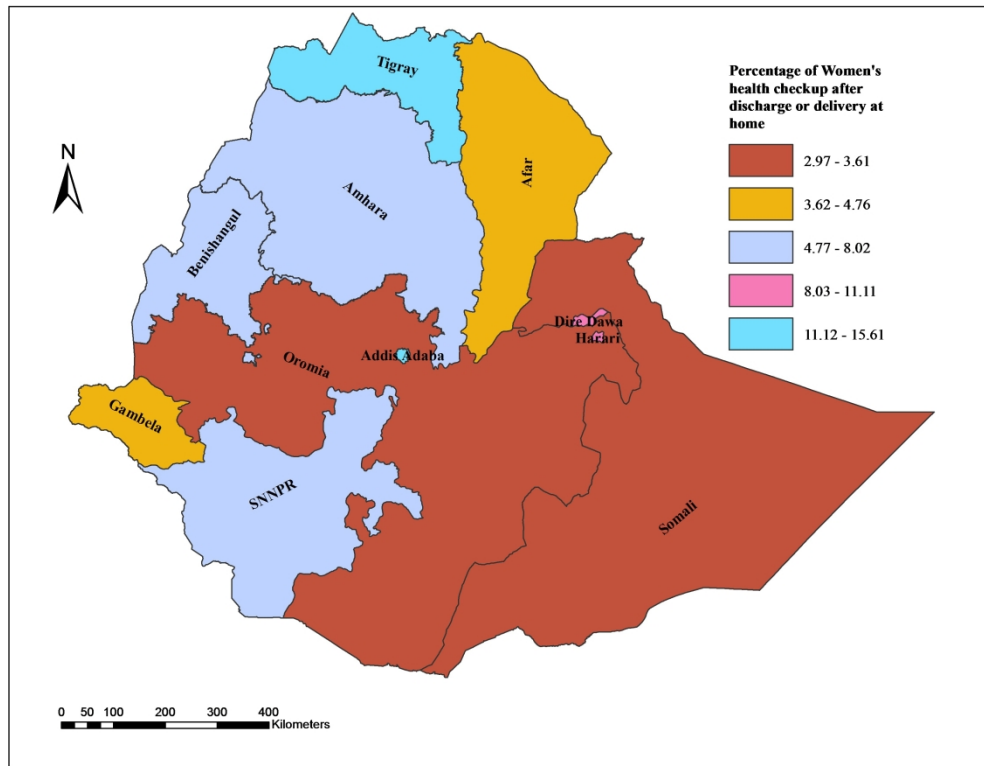
Given the z-score of 11.2181267202, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Spatial autocorrelation based on feature locations and attribute values using the Global Moran's I statistic
 267x254mm (300 x 300 DPI)



Spatial Clustering of Women's health checkup after discharge or delivery at home in Ethiopia, EDHS 2016

279x216mm (300 x 300 DPI)



Spatial distribution of Women's health checkup after discharge or delivery by percentages, Ethiopia, EDHS 2016

279x216mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	Spatial Patterns and Determinants of Postnatal Care Use in Ethiopian: A finding from Demographic and Health Survey, 2016	1
		<p>Objective: Postnatal cares (PNC) is one of the components of care to be provided to mothers and child. In Ethiopia, characterizing the spatial distribution of PNC utilization is essential to prioritize risk areas where PNC is needed and facilitate interventions. This study was aimed to explore geographical variations and identify the determinants of PNC utilization among women after delivery in Ethiopia.</p> <p>Methods: Ethiopian Demographic and Health Survey 2016 data were used and 7,193 women between 15 - 49 years of age were included in the analysis. The proportion of women who receive a health check-up after discharge and home delivery were recorded. Spatial cluster and autocorrelation analysis were done to explore the patterns of PNC utilization across the country. Multilevel logistic regression model was used to identify predictors of PNC utilization. Odds ratio with 95% confidence intervals (CI) were calculated to determine statistical significance. Mapping and spatial analysis were done using ArcGIS v10.1 software. All other data processing and analysis were done using Stata version 14 software.</p> <p>Results: The proportion of PNC utilization was 6.9 %(95% CI: 6.3%, 7.5%). There are spatial variations among regions in the country. Dire Dawa, Harari, and Jigjiga were with low utilization of PNC, whereas Tigray region utilized PNC highly at 99% confidence level. Factors including, mother with no education (AOR=0.55, 95%CL: 0.37, 0.84) and poorest wealth status (AOR=0.55, 95% CI: 0.39, 0.78) consistently predicted the lack of usage of PNC. In contrast, mothers in 35 – 49 years (AOR: 1.75, 95%CI: 1.01, 3.04) and women with at least one ANC visit (OR=2.37, 95% CI: 1.71, 3.29) were more likely to use PNC.</p> <p>Conclusion: Postnatal care utilization remains public health problem and has spatial variations at the regional level of the country. Uneducated women, young age, and poverty are barriers to PNC utilization. Educational status, wealth status, the age of mothers and ANC visits were predictors for PNC utilization. Hence, health promotion on ANC utilization and other predictors would be supreme important for better utilization of PNC.</p>	2

		Keywords: Postnatal Care, Demography and Health Survey, Women, Ethiopia	
Introduction			
Background/rationale	2	<p>In 2015, roughly 66% of the world's maternal mortality was found in Sub-Saharan Africa [1, 2]. A report in Ethiopia showed the presence of a large proportion of maternal and neonatal deaths despite the health system focusing on improving maternal health [3].</p> <p>PNC is used as an indicator of maternal health care in the post-partum period [4]. The World Health Organization (WHO) and Federal Ministry of Health (FMOH) of Ethiopia recommended that mothers must receive postnatal care at least once during the post-partum period [5-7]. Ethiopian health policies focus on maternal and child health care. As a result, maternal mortality rate decreased from 897 to 412 per 100,000 between 2000 and 2016 [6], while the antenatal care (ANC) is increased from 10.4% to 32% [8, 9]. However, PNC utilization remains very low in which only 13 to 26% of women received PNC in the last five years [10].</p> <p>Studies done in developing countries have looked into the factors associated with postnatal care utilization. Mother's Socio-demographic characteristics, including household wealth status, maternal education, maternal occupation, and residence were positively associated with PNC [11,12]. In addition, history of ANC, place of delivery and mother's knowledge of postpartum danger signs and symptoms are important predictors of postnatal care service utilization[13]. On the other hand, PNC service utilization depends on birth-related complication that can end maternal and neonatal death [14-16].</p> <p>The Ethiopian Ministry of Health has developed strategies to improve maternal and child health care utilization which is free of charge [17]. However, it is noted that the magnitude of maternal health services is heterogeneous geographically. Additionally, the extent of key barriers to PNC utilization are unexplored, which are cause maternal and neonatal death during the postnatal period. In Ethiopia, characterizing the spatial distribution of PNC utilization is essential to prioritize risk areas where PNC is needed and facilitate interventions. In another word, Understanding the levels and geographical variations of PNC utilization would help policymakers, planners, programmers and partners in the health sector to formulate appropriate strategies and interventions and provide quality reproductive health services.</p>	3 - 4
Objectives	3	Therefore, this study was aimed to explore geographical variations and identify the determinants of PNC utilization among women after delivery in Ethiopia	4
Methods			

Study design	4	We used Ethiopian Demography and Health Survey (EDHS) 2016 data which was a national representative cross-sectional survey	4
Setting	5	The study was conducted in Ethiopia, the country composed of nine Regional State and two city administrations. The country is the second most populous country in sub-Saharan Africa, with a population of over 100 million people and is a mainly rural country with only 17% of the population living in urban areas [18, 19]. Ethiopia has improvement in the coverage and utilization of the healthcare service after implementation of Health Sector Development Plan (HSDP) through decentralized in three-tier structure. Mainly, health centers provide preventative and basic curative services with referral system to the nearest high level of care [17]. Primary health cares are offered to all women free of charge including PNC in the country. In addition, the health centers composed a number of staffs such as health extension workers and health development army (HDA) to improve Universal Primary Health Care (PHC) coverage at the lowest level of administration.	4
Participants	6	The 2016 EDHS is the fourth Demographic and Health Survey conducted in the country. The study population was any women in childbearing age who gave birth in the last five years residing in the randomly selected enumeration areas (EAs). The study subjects were any women in childbearing age that gave birth in the last five years in Ethiopia.	4
Variables	7	The outcome variable of this study was women's health check-up after discharge or delivery at home (PNC utilization). Based on WHO guideline, PNC utilization defined as women who received any postpartum check after discharge from health facility or delivery at home and extends up to six weeks (42 days) after birth prior to a survey [7, 21]. The response was dichotomized as "1" if the woman received at least one health check-up after discharge or delivery at home, otherwise assigned "0". Independent variables were sociodemographic variables (age, educational level, occupation, religion, residence, region, and household wealth quintile), maternal reproductive health-related factors (place of delivery, antenatal care visit, sex of the child and health professions who checked maternal health after discharge or delivery at home).	5
Data sources/ measurement	8*	In Ethiopia, every five years, the Demographic and Health Survey program has collected data on national representative samples of all age group and key indicators including child health and maternal-related variables. Data collection took place from January 18, 2016, to June 27, 2016. EDHS datasets are available in the Measure DHS program website. After reviewing, we extracted 7,193 women data. The national shapefiles were used to maps the variations using ArcGIS 10.1.	5
Bias	9	After survey data extraction, further coding and analysis were done using STATA version 14 software.	5

		Sample weights were used to avoid geographical strata selection variability as well as for non-responses. The detailed explanation of the weighting procedure elsewhere in EDHS final report [22].	
Study size	10	The EDHS 2016 used a stratified two-stage cluster sampling design. The EAs were the primary sampling units and households were the second stage-sampling units. The survey included 15,683 women between ages 15 to 49 years old. A total of 7,193 women gave at least one birth in the last five years preceding the survey were included in the final analysis of this study.	6
Quantitative variables	11	Descriptive measures were used to summarize the overall characteristics of the study participants in the study area.	6
Statistical methods	12	<p>The spatial patterns of PNC were analysed using Geographical Information System (ArcGIS version 10.1) software. The application of GIS with spatial statistics clearly exhibited the spatial pattern of PNC. Spatial Autocorrelation analysis was performed to test whether the cases were distributed randomly over space and identified the pattern of PNC was clustered, dispersed, or random. Moran's I calculated I values as $I=0$ values was for random distribution, $I<0$ values for dispersed, and $I>0$ values for clustered [23].</p> <p>The cluster-outlier analysis (Anselin Local Moran's I) was employed to distinguish between a statistically significant ($p<0.01$) cluster of high values (High-High), cluster of low values (Low-Low), outlier in which a high value is surrounded primarily by low values (High-Low) and outlier in which a low value is surrounded primarily by high values (Low-High) [24]. A positive value for 'I' indicated that features with similar values, such type of feature surrounded the feature was part of a cluster. A negative value for 'I' indicated that features with dissimilar values surrounded the feature. Such a feature was an outlier [25].</p> <p>We applied spatial scan statistical analysis using Kuldorff's SaTScan version 9.4 software [26], to test for the presence of statistically significant spatial clusters of PNC. The spatial scan statistic uses a scanning window that moves across space [24]. The spatial patterns of PNC and its statistical significance was tested by Bernoulli probability model. With the assumption of Bernoulli probability function, we tested the null hypothesis whether there was no difference within the spatial window and outside the window. The default maximum spatial cluster size of $<50\%$ of the population was used, as an upper limit, which allowed both small and large clusters to be detected and ignored clusters that contained more than the maximum limit. For each potential cluster, a likelihood ratio test statistic was used to determine if the number of observed cases within the potential cluster was significantly higher than expected or not. The circle with the maximum likelihood ratio test statistic was defined as the most</p>	6-7

		likely (primary) cluster. The maximum observed value of the test statistic for each potential cluster was then compared with the overall distribution of maximum values. The primary and secondary clusters were identified and assigned p-values and ranked based on their likelihood ratio test, on the basis of 999 Monte Carlo replications [27, 28]. Multilevel binary logistic regression was used to calculate the measures between each of the independent variables (mother and household characteristics) and the likelihood of mothers using PNC services. The rationales for using a multilevel modelling were due to the multistage cluster sampling procedure, individual women were nested within clusters. Hence, the likelihood of women seeking maternal health services is likely to be correlated to the cluster members. Variables that had a relationship with PNC utilization ($p < 0.25$) were considered for the final model. Odds ratios with 95 % CI were used to declare statistical significance.	
Results			
Descriptive data	13*	A total of 7,193 women age 15-49 years who had at least one birth in the five years before the study period were included in the analysis. The majority 6621 (87.2%) of the respondents were rural residents. The mean age of the respondents was 29.26 years (SD \pm 6.9). About 4791(63.1%) of the respondents had no education and about one-third of the respondents were in the poorest wealth quintile. The majority of the participants were from Oromia Regional State 3130 (41.2%), followed by 1633 (21.5 %) Amhara Regional State and SNNP 1601(21.1%).	7
Outcome data	14*	The proportion of postnatal health check-up after discharge or home delivery was found to be 6.9% (95% CI: 6.3%, 7.5%), with urban, 10.6% (95% CI: 9.1, 12.2), and rural 5.9% (95% CI: 5.3, 6.6)). PNC service utilization varied across the regions of the country with the highest proportion (15%) in Tigray regional state and lowest proportion (3%) in Gambella and Somali Regional State. The proportion of women's health check-up after discharge or delivery at home in the women having antenatal care at least four visits was 10.5 % and, in the women, who delivered at a health facility, was 9.1 % (Table 1).	7
Main results	15	The global Moran's index statistic was 0.084 (p -value < 0.0001), indicating the presence of a significant positive spatial autocorrelation in women's health check-up after discharge or delivery at home in Ethiopia (Figure 1). The spatial clustering is highly pronounced at a distance of 225.2 KM with a corresponding Z score of 12.592741 (P -value < 0.0001) (Figure 2). According to LISA analysis, high clusters were observed in the major part of Tigray region (Central, eastern, western and southern Tigray) at 99% confidence level, but at 95%CI it was found at Addis Ababa town, western Tigray, North Shewa, south Shewa and East Gojjam zone of Amhara regional state, Arsis zone of Oromia region and Gurage	8-9

		<p>zone of SNNP region. In contrast, low significant clustering of women's health check-up after discharge or delivery at home were major parts of Gambella region, Harari, jigjig and Eastern Haragie (Figure 3). The SaTScan spatial analysis was identified three clusters. The primary clusters (LLR = 20.72, $p < 0.0001$) were detected in Southeastern Ethiopia. A second cluster (LLR = 19.36, $P < 0.0001$) were detected in east of Ethiopia. The final cluster (LLR = 10.91, $P = 0.048$), were in Northern Ethiopia (Table2, Figure 4).</p> <p>Despite all observations were low, relatively the highest percentage of women's health check-up after discharge or delivery at home was observed in Tigray region, 15.6% and Addis Ababa, 13.1%%, whereas the lowest observation in Somali (3.0%), Oromia (3.6%) and Afar (4.2%) (Figure 5).</p> <p>Factors associated with PNC utilization</p> <p>Demographic and socio-economic variables were selected using Enter methods at 0.25 significance level. In the final model, maternal education, wealth index and ANC visit were identified as associated factors with women's health check-up after deliver.</p> <p>Level of education showed strong statistical association with postnatal care service utilization. Mothers who have no education were about 33% times (AOR=0.55, 95%CL: 0.37, 0.84) less likely to utilize postnatal care service than educated (above Secondary) women. Similarly, the odds of poorest decreased the chance of utilizing postnatal care service by about one-third fold (AOR=0.55, 95% CI: 0.39, 0.78) less likely than richest women.</p> <p>Age of women has also been an important predictor of postnatal care service utilization. Mothers who age group in 35 – 49 years were about 1.75 times (AOR: 1.75, 95%CI: 1.01, 3.04) more likely to utilize postnatal care service utilization than younger than 19 years. Postnatal care service utilization also increased with increasing ANC visits of mothers. Women who had one to three ANC visit (OR=2.37, 95% CI: 1.71, 3.29) were more likely to receive health check-up after delivery than no Antenatal Care. Moreover, Mothers who had fourth ANC visit were about 3-fold (AOR: 3.43, 95%CI: 2.47, 4.76) more likely to utilize postnatal care service than those who had no any type of ANC visits (Table 3).</p>	
Discussion			
Key results	16	<p>Postnatal care utilization among women in Ethiopia was low and varied across socio-demographic characteristics. Regional disparity (Spatial pattern) was observed in postnatal care utilization among Ethiopian women. Higher educational level, better wealth index, antenatal care at least one visit and place of delivery were significant predictors of postnatal care utilization among women in Ethiopia. Thus, there is a need to devise such strategies, ensuring availability, accessibility and affordability of</p>	11

		<p>PNC for mother and newborn considering geographical difference. Emphasis should be given on designing public health interventions to educate and raise awareness among mothers and families regarding importance of PNC, timing for PNC check-up.</p>	
<p>Limitations</p>	<p>17</p>	<p>The study has addressed PNC utilization and spatial disparity; however, it has the following limitations. First, the analysis is designed to identify predictors of PNC and spatial patterns, but it does not point directly to explanations for these outcomes. This is a less helpful for explaining causality. Secondly, the study was represented the experiences of the participants in the 5 years that followed the study period. This might lead to recall biases, which in turn the findings may not be generalizable. Finally, there may be unmeasured variables that predict the outcomes. One example is health facility related factors like quality of services. Further research should consider the potentially important predictors.</p>	<p>10</p>
<p>Interpretation</p>	<p>18</p>	<p>This study was investigated factors and spatial variations of postnatal care utilizations among Ethiopian women using the 2016 Ethiopian DHS data.</p> <p>The study showed that Ethiopia continued to have low proportion of postnatal care (PNC) utilization. The finding was smaller than 2011 EDHS [8, 12] that indicated maternal and child health remains poor. This may be attributed to the samples difference and could be improvement in quality of data to date. It was found to below with studies done in Amhara region, Ethiopia [14, 29] and southern Ethiopia [30]. The difference might be due to our study include rural areas and study characteristics. This low result may be attributed by Programmatic problem impact on a woman's making a PNC visit and low exposure to the mass media. In comparison with other countries, Ethiopia is behind in postnatal care (PNC) utilization; including Kenya (47%)[31, 32], Nigeria (29%)[33], Nepal (40.9%)[11] and Tanzania (10.5%)[34]. This variation can also be attributed due to the time difference and could be improvement in health care utilization conducted in Kenya unlike to our study. The postnatal care (PNC) utilization is varies geographically in Ethiopia. Specifically, Tigray region and Addis Ababa city have hotspot areas. The study found that PNC was considerably varied in demographic characteristics; for example, 57% women who delivered at health facility, Orthodox religion (12.9%) and Addis Ababa residents (51.6%) were more user and PNC utilization was directly increased as level of maternal education and wealth index. This Study consistent studies conducted in Ghana and India found some geographic variations in socioeconomic inequalities [35, 36].</p> <p>This study identified several factors that indicate strong influence on the utilization of PNC services: age of mother, mother's level of education, household wealth quintile and ANC visit. Those women with no education less likely to use postnatal care as compared to women who educated more than secondary school. This finding is consistent with Nigeria [37], Kenya [32] and Nepal [11], Ethiopia[12, 14, 30, 38,</p>	<p>9-10</p>

		<p>39] and India [36]. This could be explained by the fact that education has a valuable input in enhancing female autonomy and help women develop greater confidence and capability to make decisions about their own health. Thus, literate women seek out higher quality health services and have greater ability to use health care inputs that offer better health outcomes.</p> <p>Similarly, Women in poorest wealth quintile level were less likely to use PNC as compared to richest wealth quintile in attending at least one postnatal care visit. This study is similar with evidence from study conducted in Ethiopia [12]. Our finding is also in line with others studies: Pakistan [40], Nepal and Rwanda[11, 41]. Richest Women’s may get more information of Children’s Health from mass media and health professionals privately subsequently; families may arrange institutional health services.</p> <p>Postnatal care utilization was positively associated with antenatal care service. That is Mothers who attended ANC services more frequently were more likely to receive PNC services compared to those who had attended less than one ANC services. This finding is similar with study in Nepal[11], India[36]Tanzania [34] and Kenya [32].The possible reason may be ANC users perceived that health system has provided quality care based on previous experiences. Furthermore, this could be due to variations of socio-demographic, cultural differences, which may lead to health service related to pregnancies.</p> <p>In this study, we found that mother’s older age at delivery was positively associated with PNC use. Our finding is contrast with study done in Rwanda[41]. The main reason is differences in cultural. In Ethiopia, older women were more involved in their own health care decision-making and respected than younger women. This may be reinforced that women who are empowered to make health care choices previous experiences and then older women more likely to use PNC services.</p>	
Generalisability	19	This study was a national representative in Ethiopia.	
Other information			
Funding	20	No funds received for the present study	

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

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2 **Spatial Patterns and Determinants of Postnatal Care Use in Ethiopia: Findings from the**
3 **2016 Demographic and Health Survey**
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Abstract

Objective: Postnatal cares (PNC) is essential for preventing maternal and newborn deaths; however, it still remains less well recognized in developing countries. This study was aimed to explore geographical patterns and identify the determinants of PNC utilization among age 15-49 women in Ethiopia.

Methods: A secondary data analysis was conducted using the 2016 Ethiopian demographic and health survey data. A total of 7, 193 women was included in this analysis. We employed spatial scan statistics to detect spatial inequalities of PNC utilization among women. A multilevel binary logistic regression model was fitted to identify factors associated with women's PNC.

Results: The prevalence of PNC utilization among women was 6.9 % (95% CI: 6.3%, 7.5%). The SaTScan spatial analysis identified three most likely clusters with low rates of postnatal care use namely southwestern Ethiopia (LLR = 18.07, $p < 0.0001$), southeast Ethiopia (LLR=14.29, $P < 0.001$) and eastern Ethiopia (LLR=10.18, $P=0.024$). Women with no education (AOR=0.55, 95%CL: 0.37, 0.84) and in the poorest wealth quantile (AOR=0.55, 95% CI: 0.39, 0.78) were less likely to use PNC, while women aged 35-49 years (AOR: 1.75, 95%CI: 1.01, 3.04), and at least four antenatal care visits (AOR=2.37, 95% CI: 1.71, 3.29) were more likely to use PNC.

Conclusion: Postnatal care utilization remains a public health problem and has spatial variations at regional levels in the country. Low prevalence of PNC was detected in the Somali, Oromia, Gambella and SNNPR regions. Women with low educational status, old age, being in poorest wealth quantile and history of ANC visits were significantly associated with postnatal care utilization. Hence, it is better to strengthen maternal health programs that give special emphasis could be given to health promotion with a continuum of care during pregnancy.

Keywords: Women, postnatal care, spatial, multilevel Demography and Health Survey, Ethiopia

Strengths and limitations of this study

- Having used a recent national community-based survey, the study has the potential to inform policy makers, planners and programmers to design appropriate intervention at national and regional levels.
- As a cross-sectional survey, our work is unable to draw causal conclusions. However, our method used multilevel modelling, which took into account the effect of clustering to better estimate the level of association of the study factors with the outcome
- The study was based on self-reports of respondents and provided no validation of obtaining information with an objective source. This might lead to recall bias which in turn may make the findings ungeneralizable.
- As the work is based on a secondary data analysis, some important variables, such as cultural beliefs, when women are allowed to leave the house in the postpartum period, roles of husbands in maternal health decision-making, and perceptions about whether the pregnancy is a medical issue warranting clinical visits were not available for analysis.
- In this Study, the geographic coordinates of EAs were displaced up to 5km to prevent the identification of respondents or the community. This could affect the cluster effect in the spatial analysis. So those issues should be interpreted with caution.

Background

In 2015, roughly 66% of the world's maternal mortality was found in Sub-Saharan Africa [1, 2]. A report in Ethiopia showed the presence of a large proportion of maternal and neonatal deaths although the health system is focusing on improving maternal health [3, 4].

PNC is used as an indicator of maternal health care in the post-partum period in Ethiopia [5]. According to the World Health Organization (WHO), a postnatal period is so critical for both the mother and baby that all women and newborns receive at least three postnatal contacts following delivery [6-8]. Postnatal care is an opportunity for providers to facilitate healthy breastfeeding practices, screen for postpartum depression, monitor the newborn's growth and overall health status, treat childbirth-related complications, counsel women about their family planning options, and refer the mother and baby for specialized care if necessary, among other services. In Ethiopia, maternal mortality rate decreased from 897 to 412 per 100,000 between 2000 and 2016 [7], while antenatal care (ANC) increased from 10.4% to 32% [9, 10]. However, PNC utilization remains very low as only 13 to 26% of women receive it [11].

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2 Studies in developing countries have looked into the factors associated with postnatal care
3 utilization. Mother's socio-demographic characteristics, including household wealth status,
4 maternal education, maternal occupation, and residence were positively associated with PNC
5 [12, 13]. In addition, history of ANC, place of delivery and mother's knowledge of postpartum
6 danger signs and symptoms were important predictors of postnatal care service utilization [14].
7 On the other hand, PNC service utilization depends on birth-related complication that could end
8 in maternal and neonatal deaths [15-17].

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10 Increasingly, efforts have made to improve health coverage, and expenditures expanded
11 universally; however, important maternal health inequities are concealed in smaller administrative
12 areas. Currently, the Ethiopian health care strategy is focused on primary health care units
13 including health centers, health stations, health posts, and private clinics. However, it was noted
14 that the magnitude of maternal health services has been geographically heterogeneous.
15 Additionally, the extent of key barriers to PNC utilization which cause maternal and neonatal
16 death during the postnatal period are unexplained.

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18 A spatial study is important in identifying high-risk geographic areas within a community; it also
19 helps to understand what drives disparities in low maternal health services and suggests
20 community-based interventions in the areas. Thus, understanding the spatial epidemiology of
21 postnatal care is crucial for evidence-based decision making to improve maternal health services.
22 However, studies on the spatial epidemiology of women's postnatal care are limited, and the
23 driving factors are poorly understood in Ethiopia. Hence, this study aimed to contribute pieces of
24 evidence on the geographical pattern of postnatal care and associated factors among women.

25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 **Methods**

40 41 42 43 **Data Source**

44 A secondary data analysis of the 2016 Ethiopia Demographic and Health Survey (EDHS 2016)
45 data was conducted. Ethiopia is located in the horn of Africa, the second most populous country
46 in the continent. Administratively, Ethiopia is subdivided into 11 geographical regions which are
47 sub-divided into zones and districts. The districts are further sub-divided into kebeles (the
48 smallest administrative units). Based on the 2007 population and housing census of Ethiopia,
49 each kebele administration was subdivided again into enumeration areas (EAs). These were
50 used as the primary sampling units for the fourth EDHS [18, 19]. In Ethiopia, health care service
51 has been improved after the implementation of the Health Sector Development Plan (HSDP)

1 through decentralization into a three-tier structure. Health centers mainly provide preventative
2 and basic curative services with a referral system to the nearest high level of care [4]. Primary
3 health care including PNC is offered to all women in the free of charge. The health centers are
4 staffed by health extension workers and health development army (HDA) to improve the Universal
5 Primary Health Care (PHC) coverage at the lowest level of administration.
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10 In recent years, DHS is a nationally representative survey designed to provide information on
11 health indicators at the national (urban and rural) and regional levels. As a result, the 2016 EDHS
12 was conducted by the Central Statistical Agency (CSA) with a funding support from the
13 Government of Ethiopia, the United States Agency for International Development (USAID), the
14 Government of the Netherlands, the Global Fund, Irish Aid, the World Bank, the United Nations
15 Population Fund (UNFPA), the United Nations Children's Fund (UNICEF), and UN Women. ICF
16 International also provided technical support [20]. The data used for this study were drawn from
17 2016 EDHS. The surveys used a stratified two-stage cluster sampling, which is conducted every
18 five years and the 2016 EDHS is the fourth survey in Ethiopia. In the first stage, a total of 645
19 EAs (202 in urban and 443 in rural areas) were selected with a probability proportional to EAs
20 size (PPS) from the complete list of 84,915 EAs created for the 2007 PHC sampling frame. In the
21 second stage, a fixed number of 28 households per cluster was chosen with an equal probability
22 systematic selection from the newly created household listing.
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33 The source population of this study was any women in childbearing age who gave birth in the last
34 five years preceding the survey in Ethiopia, and the study population was any women in
35 childbearing age that gave birth in the last five years preceding the survey in the selected
36 enumeration areas. In this survey, a total of 16,650 households were successfully interviewed
37 with a response rate of 98% and a total of 7,193 women in childbearing age who gave birth in the
38 last five years before the survey were included in this analysis. The 2016 EDHS data sets were
39 downloaded in SPSS format with permission from the Measure DHS website
40 (<http://www.dhsprogram.com>).
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The outcome variable of this study is postnatal care utilization status among reproductive age
women. In this study, PNC utilization is defined as women's health checkup after discharge from
a health facility or home delivery within the first six weeks (42 days) after delivery [8, 21]. The
survey collected this data from mothers' verbal reports on whether they had received PNC after
discharge from a health facility or delivery at home. We categorized this variable into "Yes" (when
a woman had received PNC at health facility) and otherwise "No". The independent variables of
this study such as socio-demographic variables (age, educational level, occupation, religion,

1 residence, region, and household wealth quintile) and maternal reproductive health-related
2 factors (place of delivery, number of antenatal care visits, sex of the child) were extracted
3 accordingly. The choice of explanatory variables was guided by the literature.
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8 **Data management and statistical analysis**

9 After data extraction, further coding and analysis were done using STATA version 14 software.
10 Sample weights were used to avoid geographical strata selection variability as well as for non-
11 responses. The detailed explanation of the weighting procedure was provided elsewhere in the
12 EDHS final report [22].
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14 Descriptive measures were used to summarize the overall characteristics of the participants in
15 the study area. A multilevel binary logistic regression analysis was used to calculate the
16 measures between each of the independent variables (mother and household characteristics)
17 and the likelihood of mothers using PNC services. The rationales for using multilevel modeling
18 were due to the multistage cluster sampling procedure, individual women were nested within
19 clusters. We used regions as cluster variables. Hence, the likelihood of women seeking maternal
20 health services is likely to be correlated to the cluster members. Variables that had a relationship
21 with PNC utilization ($p < 0.25$) were considered for the final model. Odds ratios with a 95 % CI
22 were used to declare statistical significance.
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33 **Spatial analysis**

34 The global spatial autocorrelation was assessed using the Global Moran's I statistic (Moran's I)
35 to evaluate whether the pattern was clustered, dispersed, or random across the study area using
36 ArcGIS version 10.3 [23]. A positive value for Moran's Index indicates a clustered pattern of PNC,
37 while a negative value for Moran's Index indicates a dispersed pattern [23, 24].
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39 In the presence of positive global spatial autocorrelation, we employed a purely spatial scan
40 statistics using a Bernoulli probability model to detect local clusters with a low or high rate of PNC
41 [25]. The SaTScan 9.4 software was used for the local cluster detection analysis [25, 26]. It uses
42 a circular window which moves systematically throughout the study area to identify a significant
43 SaTScan clustering of women who received PNC. The default maximum spatial cluster size of
44 <50% of the population was used as an upper limit, which allowed to detect both small and large
45 clusters and ignored clusters that contained more than the maximum limit. For each potential
46 cluster, a log-likelihood ratio test statistic was used to determine if the number of observed cases
47 within the potential cluster was significantly higher than expected or not. The circle with the
48 maximum likelihood ratio test statistic was defined as the most likely (primary) cluster, then
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1 compared with the overall distribution of maximum values. The primary and secondary clusters
2 were identified and assigned p-values and ranked based on their likelihood ratio test on the basis
3 of the 999 Monte Carlo replications [27, 28].
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8 **Patient and public involvement statement (PPI)**

9 Patients and the public were not involved in this secondary data analysis although for the original
10 project from which data was obtained, PPI participation was essential since biomarkers such as
11 anthropometry, anemia, and HIV testing were collected from households [22].
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17 **Results**

18 **Socio-demographic characteristics of participants**

19 A total of 7,193 women aged 15-49 years and had at least one birth in the five years before the
20 study were included in the analysis. The majority of 6621 (87.2%) of the respondents were rural
21 residents with a mean age of 29.3 years (SD ± 6.9). About 4791 (63.1%) of the respondents had
22 no education and about one-third were in the poorest wealth quintile. The highest number of the
23 participants, 3130 (41.2%) were from Oromia followed by 1633 (21.5 %) Amhara and 1601
24 (21.1%) SNNP states (**Table 1**).
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32 **Prevalence of postnatal care**

33 The prevalence of postnatal care utilization among women was 6.9% (95% CI: 6.3%, 7.5%) with
34 10.6% (95% CI: 9.1, 12.2) in urban and 5.9% (95% CI: 5.3, 6.6) in rural areas. PNC utilization is
35 varied across the regions of the country with a relatively highest prevalence (15%) in Tigray region
36 and the lowest (3%) in Somali. The prevalence of postnatal care was 10.5 % in women with at
37 least four visits of antenatal care, and 9.1 % in women who delivered in health facilities (**Table**
38 **1**).
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44 **Spatial distribution of PNC Utilization**

45 The global spatial autocorrelation analysis revealed a clustering pattern of women's postnatal
46 care utilization across the study areas (Global Moran's I = 0.084, p-value < 0.001) (**Figure 1**).
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49 The SaTScan spatial analysis detected a total of three statistically significant SaTScan
50 cluster areas with low postnatal care utilization. The most likely primary SaTScan cluster of areas
51 with low PNC was detected in southeast Ethiopia (LLR= 20.72, p < 0.0001), and secondary
52 cluster in east Ethiopia (LLR = 19.36, P< 0.0001). The third most likely SaTScan cluster (LLR =
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10.91, $P = 0.048$) was detected in the northern part of Ethiopia (**Table 2, Figure 2**). The highest cluster of PNC utilization was observed in Tigray region (**Figure 3**).

Factors associated with PNC utilization

Demographic and socioeconomic variables were selected using enter methods at 0.25 significance level. In the final model, maternal education, wealth index and ANC visits were identified as associated factors with women's PNC utilization after delivery.

Level of education showed a strong statistical association with postnatal care service utilization. Mothers who had no education were about 45% times (AOR=0.55, 95%CL: 0.37, 0.84) less likely to utilize postnatal care service than educated (above Secondary) women. Similarly, women belonging to the poorest wealth quintiles had 45% less chance of utilizing postnatal care service (AOR=0.55, 95% CI: 0.39, 0.78) than the richest women.

The age of women was also an important predictor of postnatal care service utilization. Mothers in the age group of 35 – 49 years were about 1.75 times (AOR: 1.75, 95%CI: 1.01, 3.04) more likely to utilize postnatal care service than women younger than 19 years. Postnatal care service utilization also increased with increasing ANC visits of mothers. Women who had one to three ANC visits (OR=2.37, 95% CI: 1.71, 3.29) were 2.37 times more likely to receive health checkups after delivery than those who had no visits. Moreover, mothers who had a fourth ANC visit were about 3-fold (AOR: 3.43, 95%CI: 2.47, 4.76) more likely to utilize postnatal care service than those who had no any type of ANC visits (**Table 3**).

Discussion

In Ethiopia, the prevalence of women's postnatal care utilization was found to be 6.9% in with marked spatial heterogeneity. The spatial scan statistics detected a total of three statistically significant SaTScan clusters of areas with low prevalence of PNC.

The study showed that Ethiopia continued to have a low proportion of postnatal care utilization. The finding was lower than the 2011 EDHS report [9, 13] which indicated that maternal and child health remained poor. This may be attributed to differences in the samples and could be an improvement in data quality to date. It was found to be below those of studies done in Amhara region, Ethiopia [15, 29] and southern Ethiopia [30]. The difference might be due to the fact that the difference in study participants socio-demographic characteristics like residency. This study included rural areas in which having low health seeking behavior, accessibility of health institution and that might hinder utilization of PNC. This low result may be attributed by the impact of programmatic problems on womans' making PNC visits and low exposure to the mass media.

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2 Compared to findings in low and middle income countries, such as Kenya (47%) [31, 32], Nigeria
3 (29%) [33], Nepal (40.9%) [12] and Tanzania (10.5%) [34], postnatal care utilization was low in
4 Ethiopia. This could be due to differences in health service accessibility, study time and the
5 quality of care across countries.
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9 A clustered pattern of areas with low and high rate of the PNC was generally observed in Addis
10 Ababa city and Tigray region, whereas low PNC rates were detected in eastern, southeastern
11 and northern part of Ethiopia. This clustered pattern could be attributed to differences in health
12 service accessibility and quality of health care. In addition, it could be the result of socio-cultural
13 differences during postnatal period activities. This finding is supported by those of studies
14 conducted in Ghana and India in which geographic variations were observed [35, 36].
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18 In the multilevel logistic regression, maternal age, educational status, household wealth quintile,
19 and ANC visits were identified as predictors of PNC. Women with no education were less likely
20 to use postnatal care as compared to women who had more than secondary school education.
21 This finding is consistent with those of studies in Ethiopia [13, 15, 30, 37, 38] and other low-
22 income countries, such as Nigeria [39], Kenya [32], Nepal [12], and India [36]. This could be
23 explained by the fact that education has a valuable input in enhancing female autonomy and
24 helping them to develop greater confidence and capability to make decisions about their own
25 health. Thus, literate women seek out higher quality health services and have a greater ability to
26 use health care inputs that offer better health outcomes.
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30 Similarly, women belonging to the poorest wealth quintile level were less likely to use PNC
31 compared to those in the richest wealth quintile who attend at least one postnatal care visit. This
32 study is similar to evidence from another study conducted in Ethiopia [13]. Our finding is also in
33 line with those of other studies: Pakistan [40], Nepal and Rwanda [12, 41]. Riche women may get
34 more information regarding PNC from mass media and may have better health care access.
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38 Postnatal care utilization was positively associated with antenatal care services. Women who had
39 a history of ANC visits were more likely to receive PNC service than their counterparts. This
40 finding is supported by these of studies in Nepal [12], India [36], Tanzania [34] and Kenya [32].
41 The possible reasons for the positive effects of ANC on PNC are that ANC offers women an entry
42 point to the health care system as well as providing counseling and awareness above the benefits
43 of PNC. Additionally, if the ANC experience was positive, women were more ready to make PNC
44 visits. Furthermore, this could be due to variations in socio-demographic and cultural , which may
45 lead to seeking health service related to pregnancies.
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2 In this study, we found that old age at delivery was positively associated with PNC use. Our
3 finding contrasts with that of a study done in Rwanda [41]. The main reason is the differences in
4 culture. In Ethiopia, adult women are more involved in their own health care decision-making and
5 enjoy better respect than younger women. This may reinforce the fact that women who are
6 empowered to make health care choices based on previous experiences of any maternal health
7 care services.
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12 The main strength of this study was its use of a nationally representative community-based study
13 with a large sample. The other strength was that we used a spatial and advanced statistical
14 approach to accommodate the hierarchical nature of the data. However, this study is not free
15 from limitations and should be mentioned. Due to the retrospective nature of the data and
16 maternal verbal reports, recall bias might have been introduced. The other limitation was that
17 DHS did not provide information about accessibility (i.e., distance to a health facility) or the quality
18 of health care providers which might influence the use of PNC among reproductive age women.
19 Lastly, the geographic coordinates of EAs are displaced up to 5km to prevent identification of
20 respondents or the community. This could affect the cluster effect in the spatial analysis. So those
21 should be interpreted with caution.
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31 **Conclusion:** This study showed that postnatal care utilization had variations in geographic areas
32 of Ethiopia. Local clusters of areas with low prevalence of PNC were detected in Somali, Oromia,
33 Gambella, and SNNPR regions. Women with low educational status, older age, poorest wealth
34 quantile, and history of ANC visits were significantly associated with postnatal care utilization.
35 Hence, the Government of Ethiopia and other stakeholders could tailor effective maternal health
36 programmes to mitigate the inequalities identified in this study. It is also good to promote health
37 education and antenatal care visit with a continuum of care. Further research is recommended to
38 investigate the reasons for regional disparities in the country.
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List of abbreviations

ANC	Antenatal Care
CI	Confidence Interval
CSA	Central Statistical Agency
DHS	Demographic and Health Survey
EA	Enumeration Area
EDHS	Ethiopia Demographic and Health Survey
FMOH	Federal Ministry of Health
OR	Odds Ratio
PNC	Post Natal Care
SD	Standard Deviation
SNNP	Southern Nations Nationalities and Peoples
SPSS	Statistical Package for Social Science
WHO	World Health Organization

Declarations

Ethics and consents

Permission was obtained to access the 2016 Ethiopia Demographic and Health Survey from the Measure DHS International Program, which authorized the data sets. All data were extracted without having any personal identifying information that could be linked to particular individuals, communities, or study participants. As the study was secondary data analysis, the research ethics was waived. Confidentiality of data was maintained.

Consent for publication

Not applicable.

Availability of data and materials

All relevant data are available within the manuscript. However, the minimal data underlying all the findings in the manuscript will be available upon request. Moreover, this study was based on an analysis of existing public domain survey data sets that is freely available online in the Measure DHS Program repository, (<http://www.dhsprogram.com>) to all registered users.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

TT, YW, AT, and DK conceptualized and designed the study. MM, MF, TT, YW, AT and DK carried out the literature review, data extraction, and analysis. MM drafted the manuscript. KA, TA, AA, and MF participate in data analysis and reviewed the manuscript. All authors read and approved the final version of the manuscript.

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Table 1: Postnatal care use by background characteristics among women age 15-49 who had given birth in the five years preceding the survey, EDHS 2016

Background characteristics	Percentage of PNC use	Number of women PNC use		
		Weighted	Unweighted	
Age (in years)	15 - 19	4.4	338	358
	20 - 34	6.6	5291	5041
	35 - 49	5.8	1960	1794
Religion	Orthodox Christian	9.4	2882	2369
	Muslim	4.0	2824	3324
	Protestant	5.5	1652	1338
	Others*	0.9	232	162
Residence	Urban	12.1	969	1512
	Rural	5.5	6621	5681
Region	Tigray	15.6	538	772
	Afar	4.2	71	647
	Amhara	8.0	1633	764
	Oromia	3.6	3130	1031
	Somali	3.0	269	806
	Benishangul	7.4	81	576
	SNNPR	6.3	1601	893
	Gambella	4.8	21	534
	Harari	11.1	18	411
	Addis Ababa	13.6	198	375
Dire Dawa	9.1	33	384	
Maternal Education	No education	4.8	4791	4359
	Primary	7.7	2150	1942
	Secondary	11.9	420	577
	Higher	13.5	229	315
Husband/partner's education level	No education	4.9	3345	3136
	Primary	6.6	2731	2160
	Secondary	9.3	612	745
	Higher	10.9	376	569
	Don't know	9.3	43	52
Wealth index	Poorest	3.1	1652	2428
	Poorer	3.9	1654	1179
	Middle	5.9	1588	1028
	Richer	8.3	1426	917
	Richest	11.8	1269	1641
ANC Visit	No ANC Visit	2.4	2818	2481
	ANC one to three visits	6.6	2342	2092
	ANC at least four visits	10.5	2429	2620
Place of Delivery	Health facility	9.1	2408	2699
	Other than Health facility	5.0	5181	4494
Sex of child	Male	5.8	3941	3718
	Female	6.8	3649	3475
Child Wanted	Wanted then	5.9	5573	5741
	Wanted later	7.9	1321	991

	Wanted no more	6.0	695	461
Birth Order	1	7.1	1434	1470
	2 - 3	7.2	2281	2217
	4 - 5	6.0	1752	1638
	6+	5.0	2122	1868

*Catholic, Traditional and other unclassified

Table 2: The most likely SaTScan clusters of areas with low prevalence of postnatal care among women in Ethiopia, 2016

Cluster	Region (Zones)	Number of clusters	Radius (km)	LLR*	p-value
1	Oromiya Region (Kelem Wollega, West Wolega, East Wollega, Kemash and Jimma), Gambella Region (Nuer and Agnuak), and SNNPR Region (Sheka, Majang, Keffa, Benchi Maji, Konta, Dawro, South Omo and Basketo Gamo goffa)	73	225.2	18.07	< 0.001
2	Oromiya region (Borena, Guji, Bale, West Arsi, West and East Hararge), Ethio-Somali Region (Doolo, Korah, Jarar and Nogab), and SNNPR (Gedio and Sidama)	39	467.6	14.19	< 0.001
3	Oromiya Region (Bale and Guji), and Ethio-Somali Region (Liben, Afder and Shabelle)	14	282.34	10.28	0.024

*Log likelihood ratio

Table 3: Factors associated with PNC utilization among Women giving birth in the last 5 years preceding the survey in Ethiopia, 2016.

	Variables	PNC use		COR (95% CI)	AOR (95% CI)
		Yes	No		
Maternal Education	Above Secondary	45	270	1.00	1.00
	No education	226	4,133	0.39(0.27, 0.56)	0.55(0.37, 0.84)
	Primary	158	1,784	0.57(0.39, 0.83)	0.69(0.46, 1.01)
	Secondary	67	510	0.81(0.54, 1.23)	0.87(0.57, 1.315)
Age (in years)	15 - 19	16	342	1.00	1.00
	20 - 34	351	4,690	1.47(0.88, 2.47)	1.47(0.87, 2.48)
	35 - 49	129	1,665	1.46(0.85, 2.51)	1.75(1.01, 3.04)
Religion	Orthodox Christian	246	2,123	1.00	1.00
	Muslim	179	3,145	0.83(0.63, 1.11)	
	Protestant	69	1,269	0.78(0.54, 1.14)	
	Others*	2	160	0.18(0.04, 0.75)	
Residence	Urban	160	1,352	1.00	
	Rural	336	5,345	0.60(0.47, 0.76)	
Wealth Index	Richest	180	1,461	1.00	1.00
	Poorest	87	2,341	0.39(0.28, 0.55)	0.55(0.39, 0.78)
	Poorer	74	1,105	0.64(0.45, 0.89)	0.75(0.54, 1.056)
	Middle	75	953	0.77(0.55, 1.07)	0.85(0.61, 1.19)
	Richer	80	837	1.06(0.78, 1.45)	0.94(0.63, 1.407)
ANC visit	No antenatal care	58	2,423	1.00	1.00
	ANC one to three visits	141	1,951	2.58(1.88, 3.54)	2.37(1.71, 3.29)
	ANC at four visits	297	2,323	4.09(3.01, 5.55)	3.43(2.47, 4.76)
Sex of child	Male	233	3,485	1.00	1.00
	Female	263	3,212	1.20(1.00, 1.45)	
Place of delivery	Health facility	266	2,433	1.00	
	Other than health facility	230	4,264	0.67(0.54, 0.82)	

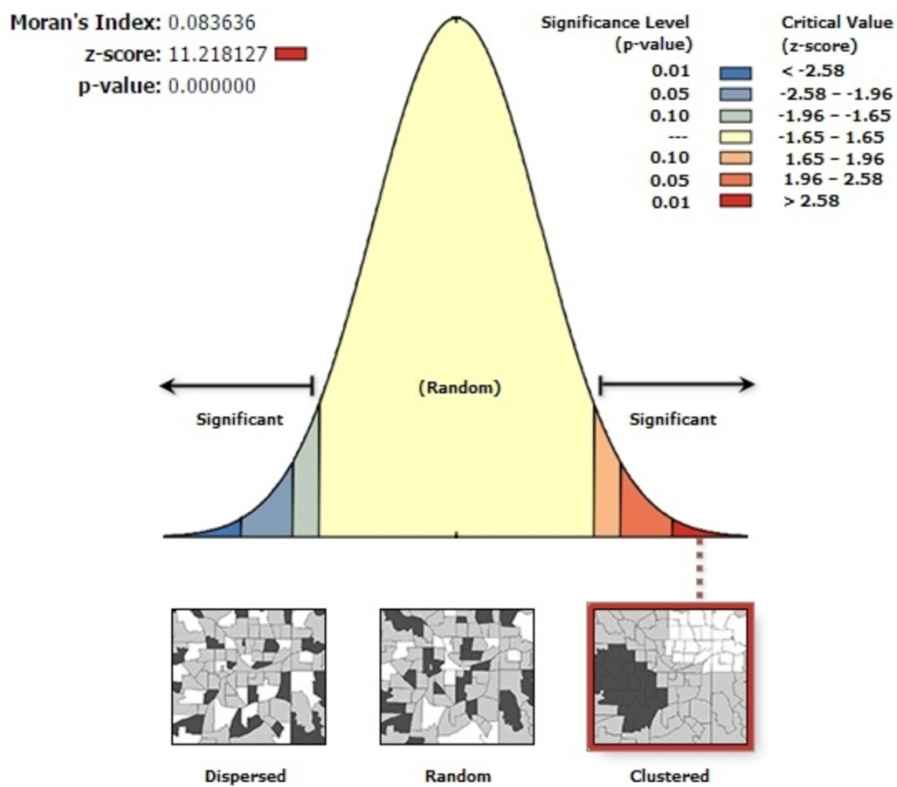
*Catholic, Traditional and other unclassified

Figure legends

Figure 1: Spatial autocorrelation based on feature locations and attribute values using the Global Moran's I statistic.

Figure 2: Spatial clustering of women's postnatal care in Ethiopia, 2016

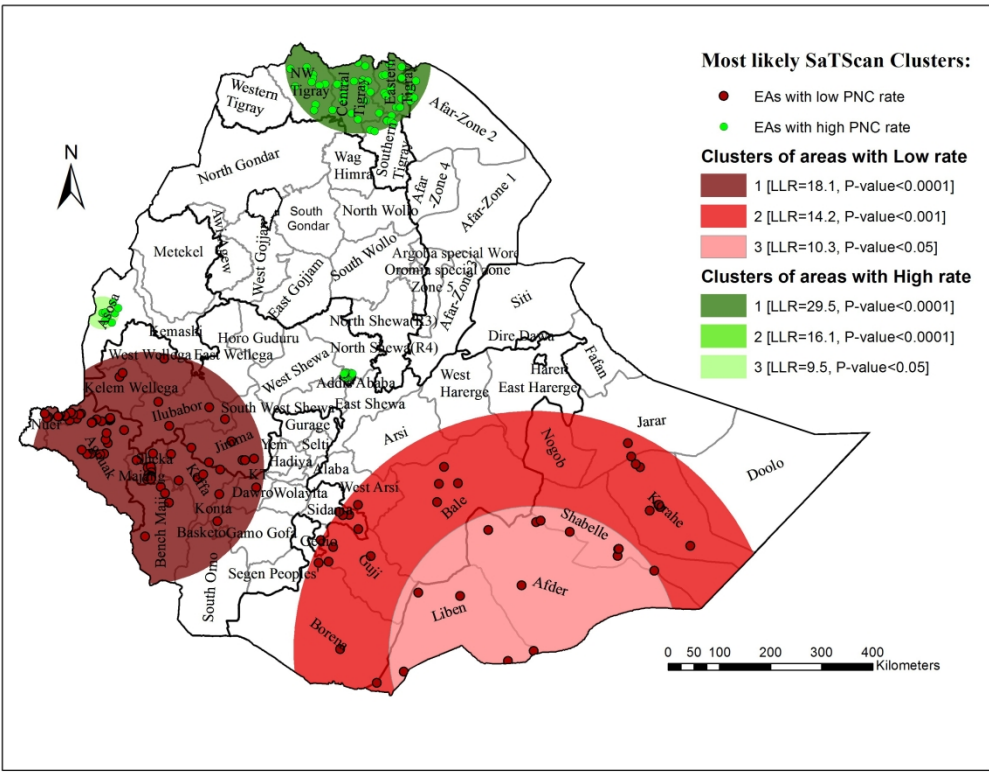
Figure 3: Percentage distribution of women's postnatal care by Region in Ethiopia, 2016



Given the z-score of 11.2181267202, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

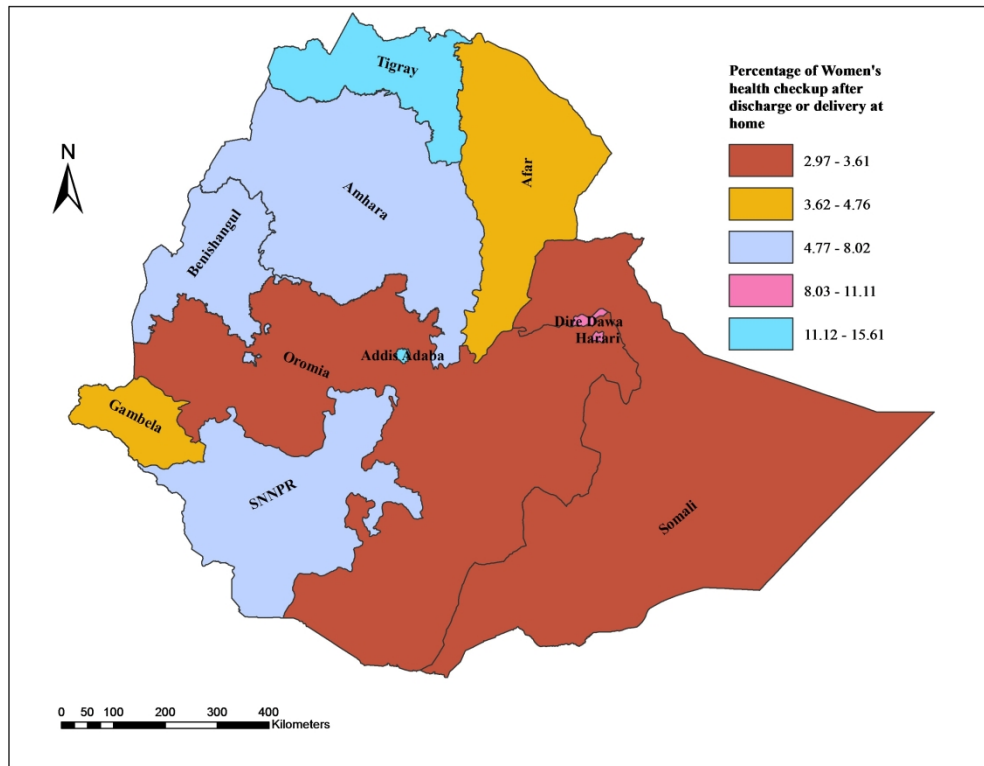
Spatial autocorrelation based on feature locations and attribute values using the Global Moran's I statistic
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Spatial Clustering of Women's health checkup after discharge or delivery at home in Ethiopia, EDHS 2016

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Spatial distribution of Women's health checkup after discharge or delivery by percentages, Ethiopia, EDHS 2016

279x216mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	Spatial Patterns and Determinants of Postnatal Care Use in Ethiopian: A finding from Demographic and Health Survey, 2016	1
		<p>Objective: Postnatal cares (PNC) is one of the components of care to be provided to mothers and child. In Ethiopia, characterizing the spatial distribution of PNC utilization is essential to prioritize risk areas where PNC is needed and facilitate interventions. This study was aimed to explore geographical variations and identify the determinants of PNC utilization among women after delivery in Ethiopia.</p> <p>Methods: Ethiopian Demographic and Health Survey 2016 data were used and 7,193 women between 15 - 49 years of age were included in the analysis. The proportion of women who receive a health check-up after discharge and home delivery were recorded. Spatial cluster and autocorrelation analysis were done to explore the patterns of PNC utilization across the country. Multilevel logistic regression model was used to identify predictors of PNC utilization. Odds ratio with 95% confidence intervals (CI) were calculated to determine statistical significance. Mapping and spatial analysis were done using ArcGIS v10.1 software. All other data processing and analysis were done using Stata version 14 software.</p> <p>Results: The proportion of PNC utilization was 6.9 %(95% CI: 6.3%, 7.5%). There are spatial variations among regions in the country. Dire Dawa, Harari, and Jigjiga were with low utilization of PNC, whereas Tigray region utilized PNC highly at 99% confidence level. Factors including, mother with no education (AOR=0.55, 95%CL: 0.37, 0.84) and poorest wealth status (AOR=0.55, 95% CI: 0.39, 0.78) consistently predicted the lack of usage of PNC. In contrast, mothers in 35 – 49 years (AOR: 1.75, 95%CI: 1.01, 3.04) and women with at least one ANC visit (OR=2.37, 95% CI: 1.71, 3.29) were more likely to use PNC.</p> <p>Conclusion: Postnatal care utilization remains public health problem and has spatial variations at the regional level of the country. Uneducated women, young age, and poverty are barriers to PNC utilization. Educational status, wealth status, the age of mothers and ANC visits were predictors for PNC utilization. Hence, health promotion on ANC utilization and other predictors would be supreme important for better utilization of PNC.</p>	2

		Keywords: Postnatal Care, Demography and Health Survey, Women, Ethiopia	
Introduction			
Background/rationale	2	<p>In 2015, roughly 66% of the world's maternal mortality was found in Sub-Saharan Africa [1, 2]. A report in Ethiopia showed the presence of a large proportion of maternal and neonatal deaths despite the health system focusing on improving maternal health [3].</p> <p>PNC is used as an indicator of maternal health care in the post-partum period [4]. The World Health Organization (WHO) and Federal Ministry of Health (FMOH) of Ethiopia recommended that mothers must receive postnatal care at least once during the post-partum period [5-7]. Ethiopian health policies focus on maternal and child health care. As a result, maternal mortality rate decreased from 897 to 412 per 100,000 between 2000 and 2016 [6], while the antenatal care (ANC) is increased from 10.4% to 32% [8, 9]. However, PNC utilization remains very low in which only 13 to 26% of women received PNC in the last five years [10].</p> <p>Studies done in developing countries have looked into the factors associated with postnatal care utilization. Mother's Socio-demographic characteristics, including household wealth status, maternal education, maternal occupation, and residence were positively associated with PNC [11,12]. In addition, history of ANC, place of delivery and mother's knowledge of postpartum danger signs and symptoms are important predictors of postnatal care service utilization[13]. On the other hand, PNC service utilization depends on birth-related complication that can end maternal and neonatal death [14-16].</p> <p>The Ethiopian Ministry of Health has developed strategies to improve maternal and child health care utilization which is free of charge [17]. However, it is noted that the magnitude of maternal health services is heterogeneous geographically. Additionally, the extent of key barriers to PNC utilization are unexplored, which are cause maternal and neonatal death during the postnatal period. In Ethiopia, characterizing the spatial distribution of PNC utilization is essential to prioritize risk areas where PNC is needed and facilitate interventions. In another word, Understanding the levels and geographical variations of PNC utilization would help policymakers, planners, programmers and partners in the health sector to formulate appropriate strategies and interventions and provide quality reproductive health services.</p>	3 - 4
Objectives	3	Therefore, this study was aimed to explore geographical variations and identify the determinants of PNC utilization among women after delivery in Ethiopia	4
Methods			

Study design	4	We used Ethiopian Demography and Health Survey (EDHS) 2016 data which was a national representative cross-sectional survey	4
Setting	5	The study was conducted in Ethiopia, the country composed of nine Regional State and two city administrations. The country is the second most populous country in sub-Saharan Africa, with a population of over 100 million people and is a mainly rural country with only 17% of the population living in urban areas [18, 19]. Ethiopia has improvement in the coverage and utilization of the healthcare service after implementation of Health Sector Development Plan (HSDP) through decentralized in three-tier structure. Mainly, health centers provide preventative and basic curative services with referral system to the nearest high level of care [17]. Primary health cares are offered to all women free of charge including PNC in the country. In addition, the health centers composed a number of staffs such as health extension workers and health development army (HDA) to improve Universal Primary Health Care (PHC) coverage at the lowest level of administration.	4
Participants	6	The 2016 EDHS is the fourth Demographic and Health Survey conducted in the country. The study population was any women in childbearing age who gave birth in the last five years residing in the randomly selected enumeration areas (EAs). The study subjects were any women in childbearing age that gave birth in the last five years in Ethiopia.	4
Variables	7	The outcome variable of this study was women's health check-up after discharge or delivery at home (PNC utilization). Based on WHO guideline, PNC utilization defined as women who received any postpartum check after discharge from health facility or delivery at home and extends up to six weeks (42 days) after birth prior to a survey [7, 21]. The response was dichotomized as "1" if the woman received at least one health check-up after discharge or delivery at home, otherwise assigned "0". Independent variables were sociodemographic variables (age, educational level, occupation, religion, residence, region, and household wealth quintile), maternal reproductive health-related factors (place of delivery, antenatal care visit, sex of the child and health professions who checked maternal health after discharge or delivery at home).	5
Data sources/ measurement	8*	In Ethiopia, every five years, the Demographic and Health Survey program has collected data on national representative samples of all age group and key indicators including child health and maternal-related variables. Data collection took place from January 18, 2016, to June 27, 2016. EDHS datasets are available in the Measure DHS program website. After reviewing, we extracted 7,193 women data. The national shapefiles were used to maps the variations using ArcGIS 10.1.	5
Bias	9	After survey data extraction, further coding and analysis were done using STATA version 14 software.	5

		Sample weights were used to avoid geographical strata selection variability as well as for non-responses. The detailed explanation of the weighting procedure elsewhere in EDHS final report [22].	
Study size	10	The EDHS 2016 used a stratified two-stage cluster sampling design. The EAs were the primary sampling units and households were the second stage-sampling units. The survey included 15,683 women between ages 15 to 49 years old. A total of 7,193 women gave at least one birth in the last five years preceding the survey were included in the final analysis of this study.	6
Quantitative variables	11	Descriptive measures were used to summarize the overall characteristics of the study participants in the study area.	6
Statistical methods	12	<p>The spatial patterns of PNC were analysed using Geographical Information System (ArcGIS version 10.1) software. The application of GIS with spatial statistics clearly exhibited the spatial pattern of PNC. Spatial Autocorrelation analysis was performed to test whether the cases were distributed randomly over space and identified the pattern of PNC was clustered, dispersed, or random. Moran's I calculated I values as $I=0$ values was for random distribution, $I<0$ values for dispersed, and $I>0$ values for clustered [23].</p> <p>The cluster-outlier analysis (Anselin Local Moran's I) was employed to distinguish between a statistically significant ($p<0.01$) cluster of high values (High-High), cluster of low values (Low-Low), outlier in which a high value is surrounded primarily by low values (High-Low) and outlier in which a low value is surrounded primarily by high values (Low-High) [24]. A positive value for 'I' indicated that features with similar values, such type of feature surrounded the feature was part of a cluster. A negative value for 'I' indicated that features with dissimilar values surrounded the feature. Such a feature was an outlier [25].</p> <p>We applied spatial scan statistical analysis using Kuldorff's SaTScan version 9.4 software [26], to test for the presence of statistically significant spatial clusters of PNC. The spatial scan statistic uses a scanning window that moves across space [24]. The spatial patterns of PNC and its statistical significance was tested by Bernoulli probability model. With the assumption of Bernoulli probability function, we tested the null hypothesis whether there was no difference within the spatial window and outside the window. The default maximum spatial cluster size of <50% of the population was used, as an upper limit, which allowed both small and large clusters to be detected and ignored clusters that contained more than the maximum limit. For each potential cluster, a likelihood ratio test statistic was used to determine if the number of observed cases within the potential cluster was significantly higher than expected or not. The circle with the maximum likelihood ratio test statistic was defined as the most</p>	6-7

		likely (primary) cluster. The maximum observed value of the test statistic for each potential cluster was then compared with the overall distribution of maximum values. The primary and secondary clusters were identified and assigned p-values and ranked based on their likelihood ratio test, on the basis of 999 Monte Carlo replications [27, 28]. Multilevel binary logistic regression was used to calculate the measures between each of the independent variables (mother and household characteristics) and the likelihood of mothers using PNC services. The rationales for using a multilevel modelling were due to the multistage cluster sampling procedure, individual women were nested within clusters. Hence, the likelihood of women seeking maternal health services is likely to be correlated to the cluster members. Variables that had a relationship with PNC utilization ($p < 0.25$) were considered for the final model. Odds ratios with 95 % CI were used to declare statistical significance.	
Results			
Descriptive data	13*	A total of 7,193 women age 15-49 years who had at least one birth in the five years before the study period were included in the analysis. The majority 6621 (87.2%) of the respondents were rural residents. The mean age of the respondents was 29.26 years (SD \pm 6.9). About 4791(63.1%) of the respondents had no education and about one-third of the respondents were in the poorest wealth quintile. The majority of the participants were from Oromia Regional State 3130 (41.2%), followed by 1633 (21.5 %) Amhara Regional State and SNNP 1601(21.1%).	7
Outcome data	14*	The proportion of postnatal health check-up after discharge or home delivery was found to be 6.9% (95% CI: 6.3%, 7.5%), with urban, 10.6% (95% CI: 9.1, 12.2), and rural 5.9% (95% CI: 5.3, 6.6)). PNC service utilization varied across the regions of the country with the highest proportion (15%) in Tigray regional state and lowest proportion (3%) in Gambella and Somali Regional State. The proportion of women's health check-up after discharge or delivery at home in the women having antenatal care at least four visits was 10.5 % and, in the women, who delivered at a health facility, was 9.1 % (Table 1).	7
Main results	15	The global Moran's index statistic was 0.084 (p -value < 0.0001), indicating the presence of a significant positive spatial autocorrelation in women's health check-up after discharge or delivery at home in Ethiopia (Figure 1). The spatial clustering is highly pronounced at a distance of 225.2 KM with a corresponding Z score of 12.592741 (P -value < 0.0001) (Figure 2). According to LISA analysis, high clusters were observed in the major part of Tigray region (Central, eastern, western and southern Tigray) at 99% confidence level, but at 95%CI it was found at Addis Ababa town, western Tigray, North Shewa, south Shewa and East Gojjam zone of Amhara regional state, Arsis zone of Oromia region and Gurage	8-9

		<p>zone of SNNP region. In contrast, low significant clustering of women's health check-up after discharge or delivery at home were major parts of Gambella region, Harari, jigjig and Eastern Haragie (Figure 3). The SaTScan spatial analysis was identified three clusters. The primary clusters (LLR = 20.72, $p < 0.0001$) were detected in Southeastern Ethiopia. A second cluster (LLR = 19.36, $P < 0.0001$) were detected in east of Ethiopia. The final cluster (LLR = 10.91, $P = 0.048$), were in Northern Ethiopia (Table2, Figure 4).</p> <p>Despite all observations were low, relatively the highest percentage of women's health check-up after discharge or delivery at home was observed in Tigray region, 15.6% and Addis Ababa, 13.1%%, whereas the lowest observation in Somali (3.0%), Oromia (3.6%) and Afar (4.2%) (Figure 5).</p> <p>Factors associated with PNC utilization</p> <p>Demographic and socio-economic variables were selected using Enter methods at 0.25 significance level. In the final model, maternal education, wealth index and ANC visit were identified as associated factors with women's health check-up after deliver.</p> <p>Level of education showed strong statistical association with postnatal care service utilization. Mothers who have no education were about 33% times (AOR=0.55, 95%CL: 0.37, 0.84) less likely to utilize postnatal care service than educated (above Secondary) women. Similarly, the odds of poorest decreased the chance of utilizing postnatal care service by about one-third fold (AOR=0.55, 95% CI: 0.39, 0.78) less likely than richest women.</p> <p>Age of women has also been an important predictor of postnatal care service utilization. Mothers who age group in 35 – 49 years were about 1.75 times (AOR: 1.75, 95%CI: 1.01, 3.04) more likely to utilize postnatal care service utilization than younger than 19 years. Postnatal care service utilization also increased with increasing ANC visits of mothers. Women who had one to three ANC visit (OR=2.37, 95% CI: 1.71, 3.29) were more likely to receive health check-up after delivery than no Antenatal Care. Moreover, Mothers who had fourth ANC visit were about 3-fold (AOR: 3.43, 95%CI: 2.47, 4.76) more likely to utilize postnatal care service than those who had no any type of ANC visits (Table 3).</p>	
Discussion			
Key results	16	<p>Postnatal care utilization among women in Ethiopia was low and varied across socio-demographic characteristics. Regional disparity (Spatial pattern) was observed in postnatal care utilization among Ethiopian women. Higher educational level, better wealth index, antenatal care at least one visit and place of delivery were significant predictors of postnatal care utilization among women in Ethiopia. Thus, there is a need to devise such strategies, ensuring availability, accessibility and affordability of</p>	11

		<p>PNC for mother and newborn considering geographical difference. Emphasis should be given on designing public health interventions to educate and raise awareness among mothers and families regarding importance of PNC, timing for PNC check-up.</p>	
<p>Limitations</p>	<p>17</p>	<p>The study has addressed PNC utilization and spatial disparity; however, it has the following limitations. First, the analysis is designed to identify predictors of PNC and spatial patterns, but it does not point directly to explanations for these outcomes. This is a less helpful for explaining causality. Secondly, the study was represented the experiences of the participants in the 5 years that followed the study period. This might lead to recall biases, which in turn the findings may not be generalizable. Finally, there may be unmeasured variables that predict the outcomes. One example is health facility related factors like quality of services. Further research should consider the potentially important predictors.</p>	<p>10</p>
<p>Interpretation</p>	<p>18</p>	<p>This study was investigated factors and spatial variations of postnatal care utilizations among Ethiopian women using the 2016 Ethiopian DHS data.</p> <p>The study showed that Ethiopia continued to have low proportion of postnatal care (PNC) utilization. The finding was smaller than 2011 EDHS [8, 12] that indicated maternal and child health remains poor. This may be attributed to the samples difference and could be improvement in quality of data to date. It was found to below with studies done in Amhara region, Ethiopia [14, 29] and southern Ethiopia [30]. The difference might be due to our study include rural areas and study characteristics. This low result may be attributed by Programmatic problem impact on a woman's making a PNC visit and low exposure to the mass media. In comparison with other countries, Ethiopia is behind in postnatal care (PNC) utilization; including Kenya (47%)[31, 32], Nigeria (29%)[33], Nepal (40.9%)[11] and Tanzania (10.5%)[34]. This variation can also be attributed due to the time difference and could be improvement in health care utilization conducted in Kenya unlike to our study. The postnatal care (PNC) utilization is varies geographically in Ethiopia. Specifically, Tigray region and Addis Ababa city have hotspot areas. The study found that PNC was considerably varied in demographic characteristics; for example, 57% women who delivered at health facility, Orthodox religion (12.9%) and Addis Ababa residents (51.6%) were more user and PNC utilization was directly increased as level of maternal education and wealth index. This Study consistent studies conducted in Ghana and India found some geographic variations in socioeconomic inequalities [35, 36].</p> <p>This study identified several factors that indicate strong influence on the utilization of PNC services: age of mother, mother's level of education, household wealth quintile and ANC visit. Those women with no education less likely to use postnatal care as compared to women who educated more than secondary school. This finding is consistent with Nigeria [37], Kenya [32] and Nepal [11], Ethiopia[12, 14, 30, 38,</p>	<p>9-10</p>

		<p>39] and India [36]. This could be explained by the fact that education has a valuable input in enhancing female autonomy and help women develop greater confidence and capability to make decisions about their own health. Thus, literate women seek out higher quality health services and have greater ability to use health care inputs that offer better health outcomes.</p> <p>Similarly, Women in poorest wealth quintile level were less likely to use PNC as compared to richest wealth quintile in attending at least one postnatal care visit. This study is similar with evidence from study conducted in Ethiopia [12]. Our finding is also in line with others studies: Pakistan [40], Nepal and Rwanda[11, 41]. Richest Women’s may get more information of Children’s Health from mass media and health professionals privately subsequently; families may arrange institutional health services.</p> <p>Postnatal care utilization was positively associated with antenatal care service. That is Mothers who attended ANC services more frequently were more likely to receive PNC services compared to those who had attended less than one ANC services. This finding is similar with study in Nepal[11], India[36]Tanzania [34] and Kenya [32].The possible reason may be ANC users perceived that health system has provided quality care based on previous experiences. Furthermore, this could be due to variations of socio-demographic, cultural differences, which may lead to health service related to pregnancies.</p> <p>In this study, we found that mother’s older age at delivery was positively associated with PNC use. Our finding is contrast with study done in Rwanda[41]. The main reason is differences in cultural. In Ethiopia, older women were more involved in their own health care decision-making and respected than younger women. This may be reinforced that women who are empowered to make health care choices previous experiences and then older women more likely to use PNC services.</p>	
Generalisability	19	This study was a national representative in Ethiopia.	
Other information			
Funding	20	No funds received for the present study	

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.