

Spatial Clustering of Maternal Health Services Utilization and Its Associated Factors in Tanzania: Evidence From Tanzania Demographic Health Survey 2015-16

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Abstract

Background: Maternal healthcare services are major component for the health outcomes of the pregnant woman in making sure the deaths of mother and child are prohibited. This study aimed to examine the spatial clustering of maternal health care services utilization and the associated factors in Tanzania.

Methods: The study utilized the Tanzania Demographic Health Survey and Malaria Indicators Survey 2015-16 data. The study carried out to 7,013 women aged between 15 and 49 years who had a live birth in the five years preceding the survey. Spatial analysis was done using the Bernoulli model through Kullodorff scan statistics, and multiple logistic regression analysis was employed to identify the predictors of maternal health services utilization

Results: Spatial variations of antenatal care visit and delivery care across the regions was observed. Spatial scan statistic identified high utilization performing cluster for antenatal care centroid in Morogoro Region [RR=1.67, $p<0.001$] and low utilization in Kaskazini Pemba Region [RR=0.38, $p<0.001$]. For delivery care utilization, high utilization was observed in Mtwara Region [RR=1.83, $p<0.001$] and low utilization in Kigoma Region [RR=0.41, $P<0.001$]. Utilization of antenatal and delivery care services was higher among women from the richest households, with fewer children, living in urban areas and had acquired a higher education level.

Conclusion: Results permit more insight into the differences in maternal health service utilization in relation to demographic characteristics in the country. In addition, findings highlight areas with low utilization performing clusters. Such finds are beneficial in the implementation of policy and intervention to expand maternal health care uptake in cross the regions.

Background

Maternal mortality has remained global health challenges in developing countries (1). The report revealed that complication during delivery and pregnancy period take the lives of millions of women every year. It has been also observed that between 1990 and 2015 more than 10.7 million women die due to birth complication (2). The situation is worse in Sub-Saharan countries because many pregnant women cannot access health facilities at the right time and in the right place (3). Low and middle-income countries have attempted several techniques to reduce the existing problem. Up to now, very few strategies have managed to overcome the challenge (4). In Tanzania, the current report shows that the estimated maternal mortality rate was 556 per 100,000 live births (5). It implies that Tanzania is still far from Sustainable Development Goals (SDG) targets of decreasing maternal mortality rate to 70 per 100,000 live births (1).

There has been significant research in the world to understand the causes of maternal mortality. For example, it was found that low quality of care and poor accessibility of maternal health care services as the source of the maternal mortality (6, 7). Similar findings have reported the inadequacy of quality of maternal health care services throughout pregnancy, delivery and the postpartum (8, 9). Maternal health care services (MHS), including Antenatal care (ANC) delivery care and the postpartum period, are proven maternal health indicators that can reduce maternal mortality and taken as major components of safe motherhood (10). Previous studies have used maternal health indicators as a pathway to track the progress of Sustainable Development Goal (SDGs) toward maternal mortality reduction (11,12). In most developing countries data on maternal

mortality are not readily available and many researchers have been using maternal health care services indicators as proxies for maternal mortality (13).

Various studies indicate that many factors are influencing the utilization of maternal health services among pregnant women including demographic and household characteristics (14–16). Some of the researchers included demographic characteristics in their studies but the location of the households and distance to health facilities were not considered (17–19). The two variables are important because for balancing resources which affect the utilization of maternal health care services in the country (20).

Different spatial statistical analyses and geographical information system have been progressively used in epidemiology to examine the disease and non-disease distribution patterns and also the associations between health events and correlates (21–23). Although research on spatial patterns has focused on the disease rather than non-disease health outcome (23,24). The geographic variation of maternal health care utilization would provide information for policy-makers and planners in the health sectors to target the use of limited resources of maternal health indicators in risk areas. Therefore, this paper examines the spatial clustering of maternal health care services utilization and their determinants among reproductive women aged 15-49 years in Tanzania.

Methods

Study design

This study extracted data from a national population-based survey of 2015-16 (25). An individual data set of reproductive women aged between 15 and 49 years and GPS files were downloaded from www.dhsprogram.com. The location (latitude and longitude) of the individual from the GPS data set were merged with the individual data using the cluster identification number.

Study population

The target population was all women of childbearing age between 15 to 49 years. The focus was on women who had a live birth in the five years preceding the survey. The most recent delivery was considered for women with two or more live births during the five years.

Sampling procedure and sample size

The sample was based on enumeration areas (EAs) of the 2012 Tanzania Population and Housing Census (26). A total of 608 clusters and 13,376 households were selected. All women aged between 15 and 49 years in the households were qualified for the interview. A total of 13,266 women were identified of which 7,013 reproductive women aged 15 and 49 years who had given birth in the past five years preceding the survey were included in this study.

Measures

Variables used in this study were obtained after reviewing various literature. Two outcome measures of maternal health care services were considered; antenatal and delivery care.

ANC visit was coded as,

$$Y_i = \begin{cases} 1 & \text{if the woman had attended at least 4 ANC visit} \\ 0, & \text{otherwise} \end{cases}$$

and place of delivery was coded as,

$$Y_i = \begin{cases} 1 & \text{if the woman delivery in health facility} \\ 0, & \text{otherwise} \end{cases}$$

Explanatory variables included the area of residence, age of the women, education level, household wealth index, marital status and parity.

Data analysis

The extracted data were analyzed using STATA version 14 and SaTScan version 9.8. The univariate and bivariate analysis was used to obtain women's demographic characteristics and the association between the outcome variables and independent variables respectively. The multiple logistic model determined the effect of collective independent variables on the outcome variables. Odds Ratios (OR) and 95% Confidence Interval (CI) were computed to measure the effect of explanatory variables on the outcome variable.

Kulldorff's Spatial Scan statistics method was applied to detect clusters with high and low utilization of antenatal and delivery care. The maximum likelihood of having high utilization of antenatal and delivery care denoted the performing cluster. Other clusters apart from the most likely cluster were considered as the secondary clusters. The method arranges these clusters depending on the value of likelihood ratio test statistic and p-values. The Monte Carlo hypothesis testing provided the p-values by associating the rank of maximum likelihood of the actual dataset with that of the random dataset (27). This study defines the maximum cluster with a size of 50% of the total population.

A Bernoulli model was used to identify events occurred at a particular place whether the women use maternal health care services (ANC visit and health facility delivery) or not represented by a 0/1 variable. Reproductive women aged between 15 and 49 years who had given birth in the past five years preceding the survey in the household but had never or attended less than the recommended number of ANC visits, and use non-health facility for delivery were included as a control.

Ethical considerations

The Medical Research Coordinating Committee (MRCC) granted ethical approval for DHS to conduct the survey. The approval to use the data for this study was requested and received from the DHS MEASURE.

Results

Sample characteristics

Results in Table 1 presents the social-demographic characteristics of women involved in this study. It was revealed that 72.99% of respondents resided in rural areas and 26.01% resided in urban areas. It was noted that 65.72% of women were aged between 20 and 34 years and 7.81% were below 20 years. As regards education, it was found that 60.62% of the respondents had primary education and 19.48% never attended any formal education. It was further revealed that 21.97% of women were from richer households, while 20.52% were from poorest households. Findings indicated further that 81.55% of the women were married and 6.43% were single. Regarding the number of children, the results indicated that 71.57% of women had between one to four children. About 50% of women adhered to the suggested number of antenatal care visits and the remaining 50% of pregnant women did not adhere to the suggested number of antenatal care visits. The percentage of the respondents was higher (67.20%) among those who reported using health facility for delivery and it was 32.80% for those who did not use health facility for delivery.

Identified clusters with high utilization of antenatal and delivery care services

A total of 608 sample points for 2015-16 TDHS-MIS data was used to test hypotheses for high and low utilization of maternal health care. Clusters with high utilization of more than four antenatal care visits and health facility delivery care are presented in Table 2 and Figure 1. A significant cluster with the high utilization of antenatal care visits was identified. The most likely cluster was detected with 305 sample points centralized at coordinates (-8.15383⁰ S, 36.68966⁰ E) in Morogoro Region. The cluster covers the radius 439.86km, which include Manyara, Tanga, Pwani, Lindi, Mtwara, Ruvuma, Njombe, Mbeya, Iringa, Singida, Dodoma, Tabora, Dar es Salaam, Kusini Unguja, Kaskazini Unguja and Kilimanjaro regions. Women in the most likely cluster were 67% more likely to attend more than four antenatal care visits throughout the pregnancy period compared to women in other clusters [RR=1.67, p<0.001].

Regarding the place of delivery, the study identified four clusters. The most likely cluster with sample points 210 was centralized at coordinate (-10.9218⁰ S, 38.11758⁰ E) in Mtwara Region. The cluster covers the radius of 545km, which include Mbeya, Iringa, Dodoma, Morogoro, Pwani, Kusini Unguja, Dar es Salaam, Lindi, Njombe, Ruvuma and Mtwara region. Women in the most likely cluster were 83% more likely to delivery at a health facility compared to women in other clusters [RR=1.83, p<0.001].

Identified clusters with low utilization of antenatal and delivery care services.

This study further identified eight and fifteen significant clusters with the lowest utilization of antenatal care and delivery care, respectively, as shown in Table 3 and Figure 2. The most likely cluster for lowest utilization of antenatal care services with 13 sample points was centralized at coordinates (-4.94153⁰ S, 39.74770⁰ E) in Kaskazini Pemba. The cluster covers a radius of 20.35 km, which included Kaskazini Pemba region only. Women in the most likely cluster were 62% less likely to have an adequate rate of the number of antenatal care visits compared to women in other clusters [RR= 0.38, p<0.001].

Concerning the place of delivery, the most likely cluster of low utilization of health facility delivery with 13 sample points was centralized at coordinates (-3.19546⁰ S, 30.86875⁰ E) in Kigoma Region. The cluster covers a radius of 127.36 km, which include Katavi, Tabora and Kigoma regions. Women in this cluster were 59% less likely to deliver at a health facility compared to women in other clusters [RR=0.41, p<0.001].

Factors related to the utilization of antenatal care and delivery care services

The findings of this study show residence areas, level of education, wealth index, the number of living children are significant for antenatal care utilization in both univariate and bivariate analysis (Table 4). The multiple logistic regression analysis shows that women with secondary and higher education level were 36% more likely to make more than four ANC visits service than uneducated women [AOR= 1.36; 95% CI= 1.14 -1.62]. It was also observed that women with primary education were 17% more likely to make more than four ANC visits than uneducated women [AOR= 1.17; 95% CI= 1.03-1.33]. The utilization of more than four ANC visits was relatively proportional to household-wealth status. Thus women from most affluent households were 38% more likely to adhere to the recommended number of ANC visits than those from richest households [AOR: 2.38, 95% CI= 1.94-2.91]. Women with more than five children were 40% less likely to utilize antenatal care services than women without children [AOR=0.60, 95% CI= 0.36-0.99, $p < 0.05$].

The relationships between the socio-demographic characteristics and utilization of place of delivery are shown in Table 5. The results of the univariate and bivariate analysis indicate that residence, women age, level of education, household wealth index and the number of living children were related to the utilization of delivery services.

The results indicate that women who belong to rural areas were 54% less likely [AOR=0.46, 95% CI= 0.38-0.56] to use health facility delivery care than those in urban areas. Findings further revealed that women with secondary and higher educational level were 60% more likely to use health facility delivery care [AOR= 2.60, 95% CI: 2.10-3.23] compared to uneducated women. Regarding wealth indices, the odds of health facility delivery care increased with an increase in household-wealth status. Thus, women from the richest wealth status were 40% more likely to use health facility for delivery relative to women in the poorest wealth status [AOR= 5.40, 95% CI= 4.11-7.10].

Discussion

This study examined the spatial clustering of the utilization of maternal health care and its correlates among the reproductive women aged between 15 and 49 years in Tanzania. The results reveal significant spatial variation in the utilization of antenatal and delivery care services. Clusters with high and low utilization of antenatal care and delivery care were identified. The study identified Kaskazini Pemba and Kigoma as a region with a low utilization rate of antenatal and delivery care services respectively. These areas require significant effort to impart knowledge to improve the uptake rate of antenatal care visit and delivery care services. The influence of geographical variation in relative to maternal health care utilization was also noted in (20,28,29).

The WHO endorsed that at least 69% of low-risk expectant women in Sub-Saharan Africa must attend at least one ANC visit (28). In this study, the results indicated that 50.34% of the pregnant women have an inadequate number of antenatal care visits and 49.66% have an adequate number of antenatal care visits, which is low as compared to the WHO recommendation. Thus, more effort is required to progress the low rate of ANC care utilization.

The study also reveals that rural women were less likely to utilize maternal health care services compared to urban women. These findings concur with the results of (30–34) which found the influence of residence on the utilization of maternal health care. This difference may be due to availability of better transportation systems to access maternal health services in the urban area.

Regarding the level of education, use of antenatal care and delivery care are in line with those presented by (15,17,18,35) that education significantly influences the use of maternal health care. This may be due to the reason that educated women are more likely to understand the advantage of using the components of maternal health services during the pregnant period; therefore, it increases the likelihood of using it.

It is also observed that wealth indices are statistically associated with the use of maternal health services. Similarly, the use of maternal health care increases with the wealth quartile of the women, whereby women from the wealthiest households are more likely to use antenatal care and delivery care than those in more impoverished households. Results are supported by numerous scholarships that household wealth status influences the use of maternal health care services (29,36).

Moreover, there is a significant relationship between the number of living children and the use of antenatal care. The results have shown that the odds of women attending ANC visit decrease as the number of children increases. Literature shows that women with more children have a habit of using maternal health services less frequently compared to women with few children (15, 33, 34). This may be due to the knowledge concerning the pregnancy for a new mother that they can have a fear of risk associated with her pregnancy which will make her have frequent use of maternal health care.

Conclusion

This study points out that low utilization in maternal health care services is spotted in a specific area in Tanzania. Among the spotted clusters, Kaskazini Pemba and Kigoma regions appeared with low utilization of both antenatal and delivery care. Women from wealthy households, households with a fewer number of children, educated and residing in urban areas are more likely to use maternal health care. These results provide an adequate avenue in understanding the situations of antenatal care and delivery care utilization in the regions of Tanzania. The findings inform policymakers and health experts to implement effective and timely interventions in high-risk areas.

Abbreviations

ANC: Antenatal care; TDHS-MIS: Tanzania Demographic Health Survey and Malaria Indicator Survey; WHO: World Health Organization, AOR: Adjusted Odds Ratio.

Declarations

Ethical approval and consent to participate

The Medical Research Coordinating Committee (MRCC) granted ethical approval for DHS to conduct the survey. The approval to use the data for this study was requested and received from the DHS MEASURE.

Availability of data and material

The utilized datasets are available upon request to www.dhsprogram.com.

Consent of publication

Not applicable

Competing interests

The authors declare that they have no competing interest.

Authors' contributions

BT has made substantial contributions to the conception, design of the work, drafting of the manuscript, analysis and interpretation of data. AM has provided her expertise on the use of SaTScan software on analysis of maternal health services utilization, and MM has provided editorial work and writing assistance. All authors read and approved the final manuscript.

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Tables

Table1: Socio-demographic characteristics of selected women (n=7, 013), TDHS-MIS 2015-

Variables	Codes	Number (%)
	1= urban	1824(26.01)
Residence	2= rural	5189(72.99)
	1= Less than 20	548(7.81)
Women age	2= 20-34	4609(65.72)
	3= 35-49	1856(26.47)
	0 = No education	1366(19.48)
Educational level	1 = Primary education	4251(60.62)
	2 = Secondary and Higher	1396(19.91)
	1 = Poorest	1439(20.52)
	2 = Poorer	1356(19.34)
Wealth	3 = Middle	1376(19.62)
	4 = Richer	1541(21.97)
	5 = Richest	1301(18.55)
	0 = Single	45 (6.43)
Marital status	1 = Married	5719(81.55)
	2 = Widowed	843 (12.02)
	0 = 1	71(1.01)
No of living Children	1= 1-4	5019(71.57)
	2 = 5+	1923(27.42)

Number of ANC visits	0 = Inadequate visits (less than 4 visit)	3530 (50.34)
	1 = Adequate visits (more than 4 visit)	3483 (49.66)
Place of delivery	0 = Non-health facility	2300(32.80)
	1= Health facility	4713(67.20)

Table 2: Clusters with the high utilization of antenatal care and delivery care services TDHS-MIS 2015-16

Number of antenatal care								
Cluster Type	Centroid	Latitude	Longitude	Radius	Sample points	P-Value	Relative Risk	Region with centroid
Most Likely	90	-8.15383	36.68966	439.86	305	0.000	1.67	Morogoro
Delivery care								
Cluster type	Centroid	Latitude	Longitude	Radius	Sample points	P-Value	Relative Risk	Region with centroid
Most likely	196	-10.92183	38.11758	545.00	210	0.000	1.83	Mtwara
Secondary	23	-3.24586	36.98748	39.09	14	0.000	1.69	Tanga
Secondary	70	-5.07954	39.09726	69.27	12	0.000	1.53	Kilimanjaro
Secondary	390	-2.54834	32.92563	8.16	5	0.005	1.64	Mwanza

Table 3: Clusters with the low Utilization of Antenatal Care and Delivery Care, TDHS-MIS 2015-16

Number of antenatal care								
Cluster Type	Centroid	Latitude	Longitude	Radius	Sample points	P-Value	Relative Risk	Region with centroid
Mostly Likely	587	-4.94153	39.74770	20.35	13	0.000	0.38	Kaskazini Pemba
Secondary	340	-3.19546	30.86875	94.85	14	0.000	0.52	Kigoma
Secondary	359	-4.17777	32.03732	46.77	5	0.000	0.38	Shinyanga
Secondary	604	-5.33083	39.78779	6.40	4	0.000	0.27	Kusini Pemba
Secondary	485	-7.112338	31.43694	86.03	12	0.000	0.58	Katavi
Secondary	399	-2.163879	32.15195	72.04	12	0.000	0.56	Kagera
Secondary	352	-3.509063	33.12594	0.00	1	0.002	0.07	Shinyanga
Secondary	492	-2.993746	34.22590	40.64	8	0.038	0.64	Simiyu
Place of delivery								
Cluster Type	Centroid	Latitude	Longitude	Radius	Sample points	P-Value	Relative Risk	Region with centroid
Most Likely	337	-5.18130	30.99442	127.36	13	0.000	0.41	Kigoma
Secondary	492	-2.99375	34.22590	77.74	19	0.000	0.54	Simiyu
Secondary	526	-2.94269	31.59055	102.51	25	0.000	0.59	Geita
Secondary	594	-5.32698	39.80520	43.24	29	0.000	0.63	Kaskazini Pemba
Secondary	441	-5.48361	37.25677	84.97	11	0.000	0.48	Manyara
Secondary	292	-5.70289	33.96951	63.02	3	0.000	0.45	Tabora
Secondary	438	-3.92048	36.51063	51.54	2	0.000	0.15	Manyara
Secondary	39	-3.02414	36.29140	0.00	1	0.000	0.00	Arusha
Secondary	483	-7.09008	31.165882	80.65	13	0.001	0.67	Katavi
Secondary	529	-5.86368	39.279874	10.62	7	0.002	0.54	Kaskazini Unga
Secondary	310	-8.37629	32.048961	0.00	1	0.002	0.00	Rukwa
Secondary	2	-4.36409	35.852918	0.00	1	0.013	0.00	Dodoma
Secondary	267	-4.62602	34.683489	15.65	3	0.025	0.39	Singida
Secondary	350	-3.39605	32.943685	59.81	12	0.033	0.74	Shinyanga

Secondary	406	-1.42993	34.762784	111.90	16	0.041	0.76	Mara
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Table 4: Odds ratios and 95% Confidence Interval (CI) by ANC care utilization, TDHS-MIS 2015-16

Covariates	Crude odds ratio	Adjusted odds ratio	Overall-P value
	OR (95% CI)	AOR (95% CI)	
Residence			<0.001
Urban	<i>Ref</i>	<i>Ref</i>	
Rural	0.55 (0.49-0.61) ^{***}	0.94 (0.82 -1.09)	
Women age group			0.203
< 20	<i>Ref</i>	<i>Ref</i>	
20-34	1.19 (1.00 -1.43) ^{**}	1.12 (0.93 - 1.35)	
35-49	1.02 (0.85 - 1.24)	1.32 (1.05 -1.65) ^{**}	
Level of education			<0.001
No education	<i>Ref</i>	<i>Ref</i>	
Primary education	1.42 (1.25 - 1.60) ^{***}	1.17 (1.03 -1.33) ^{**}	
Secondary and Higher	2.40 (2.06 -2.798) ^{***}	1.36 (1.14 - 1.62) ^{***}	
Wealth			<0.001
Poorest	<i>Ref</i>	<i>Ref</i>	
Poorer	1.16 (0.99 -1.34) [*]	1.13 (0.97 - 1.31)	
Middle	1.34 (1.15 -1.56) ^{***}	1.26 (1.08 - 1.47) ^{***}	
Richer	2.01 (1.74 -2.33) ^{***}	1.74 (1.49 - 2.04) ^{***}	
Richest	3.10 (2.65 -3.62) ^{***}	2.38 (1.94 - 2.91) ^{***}	
Marital Status			0.563
Single	<i>Ref</i>	<i>Ref</i>	

Married	0.88 (0.72 - 1.06)	1.11 (0.91 - 1.36)
Widowed	1.00 (0.79 - 1.26)	1.22 (0.96 - 1.55)
<i>No of living children</i>		<0.001
0	<i>Ref</i>	<i>Ref</i>
1-4	0.99 (0.62 - 1.58)	0.92 (0.57 - 1.50)
5+	0.59 (0.37 - 0.94)**	0.60 (0.36 - 0.99)**

Significance level: ***= $p < 0.01$, **= $p < 0.05$, *= $p < 0.1$, *Ref* reference categories

Table 5: Odds ratios and 95% Confidence Interval (CI) by delivery care utilization, TDHS 2015-16

Covariates	Unadjusted	Adjusted	Overall-P-value
	OR (95% CI)	AOR (95%CI)	
Residence			<0.001
Urban	<i>Ref</i>	<i>Ref</i>	
Rural	0.19 (0.16 - 0.22)***	0.46 (0.38 - 0.56)***	
Women age			<0.001
< 20	<i>Ref</i>	<i>Ref</i>	
20-34	0.96 (0.79 - 1.16)	0.86 (0.70 - 1.07)	
35-49	0.75 (0.61 - 0.92)***	1.20 (0.93 - 1.55)	
Level of education			<0.001
<i>No education</i>	<i>Ref</i>	<i>Ref</i>	
Primary education	2.38 (2.10 - 2.70)***	1.70 (1.49 - 1.94)***	
Secondary and Higher	7.6 (6.28 - 9.15)***	2.60 (2.10 - 3.23)***	
Wealth			<0.001
Poorest	<i>Ref</i>	<i>Ref</i>	
Poorer	1.40 (1.21 - 1.63)***	1.37 (1.17 - 1.59)***	
Middle	2.12 (1.82- 2.47)***	1.85 (1.58 - 2.16)***	
Richer	4.46 (1.82-2.47)***	2.80 (2.35-3.34)***	
Richest	14.37(11.41- 18.09)***	5.40 (4.11 - 7.10)***	
Marital Status			0.053
Single	<i>Ref</i>	<i>Ref</i>	
Married	0.48 (0.38 - 0.61)***	0.86 (0.66 - 1.12)	
Widowed	0.58 (0.45 - 0.77)***	0.96 (0.71 - 1.29)	
No of living children			<0.001
0	<i>Ref</i>	<i>Ref</i>	
1-4	1.20 (0.73 - 2.00)	1.36 (0.79 - 2.37)	

5+

0.49 (0.30 - 0.82)***

0.70 (0.39 - 1.23)

Significance level: *** = $p < 0.01$, ** = $p < 0.05$, * = $p < 0.1$, Ref reference categories

Figures

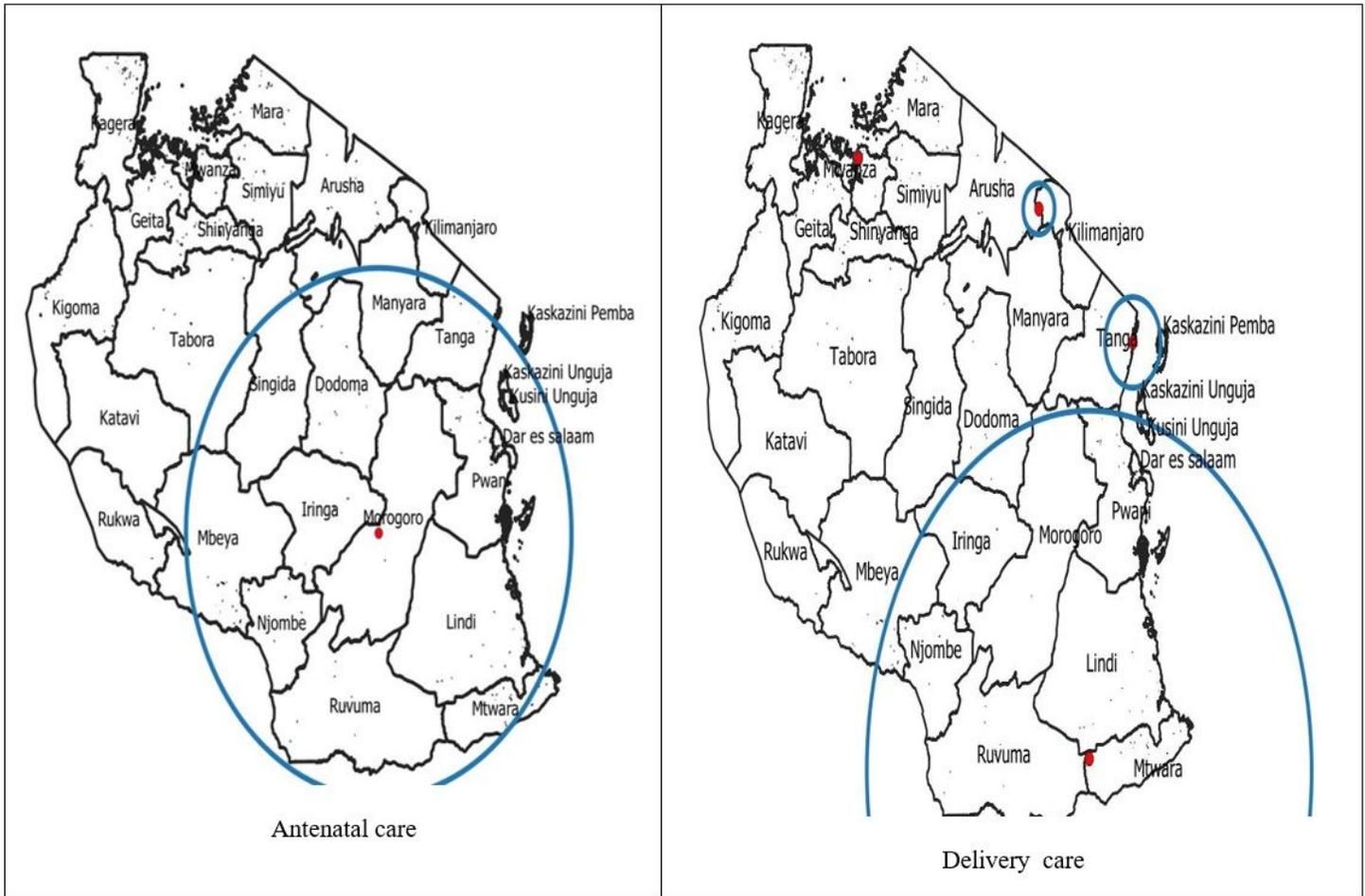


Figure 1

Clusters with the high utilization of antenatal care and delivery care from TDHS-MIS 2015-16 Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

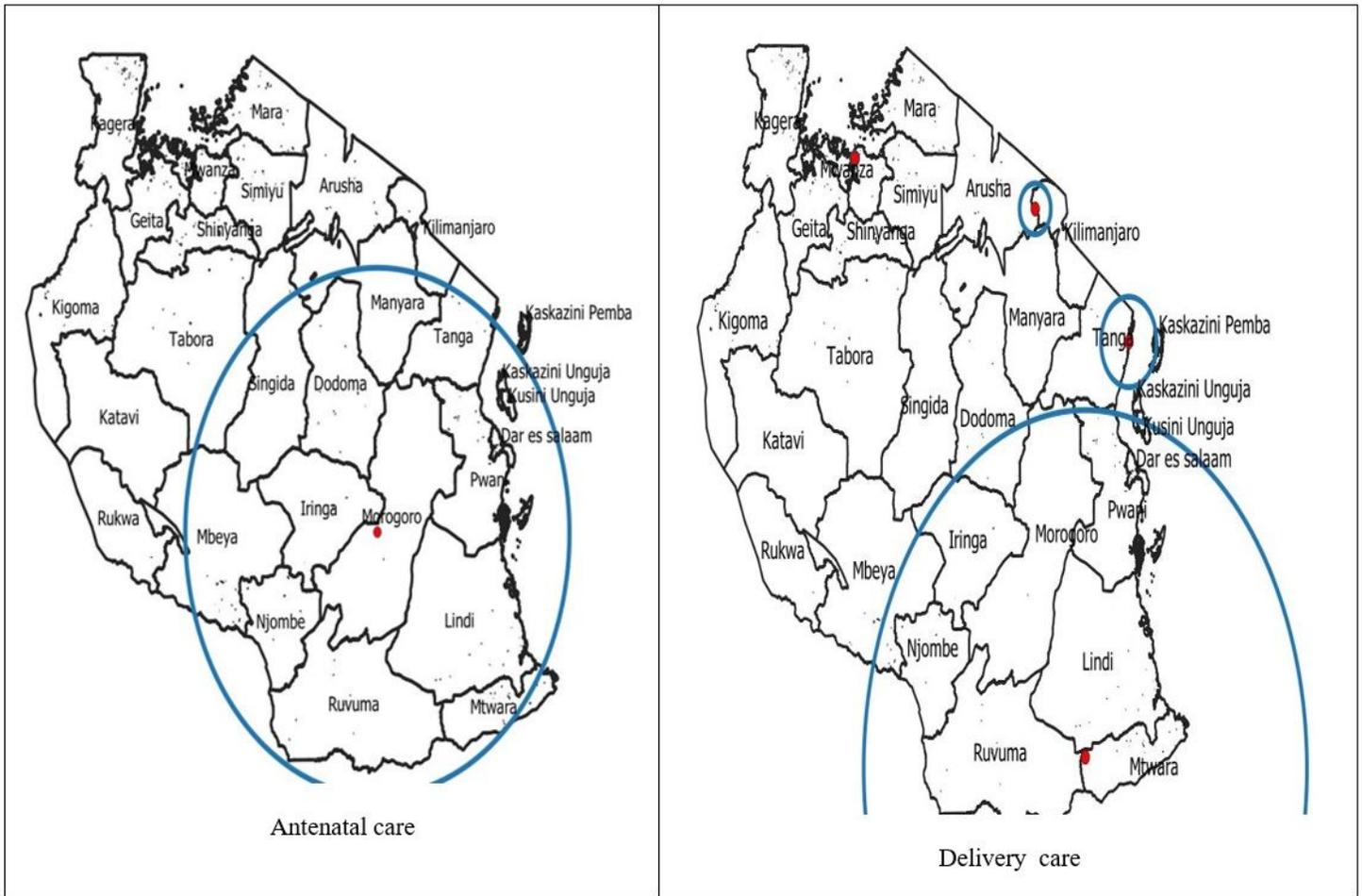


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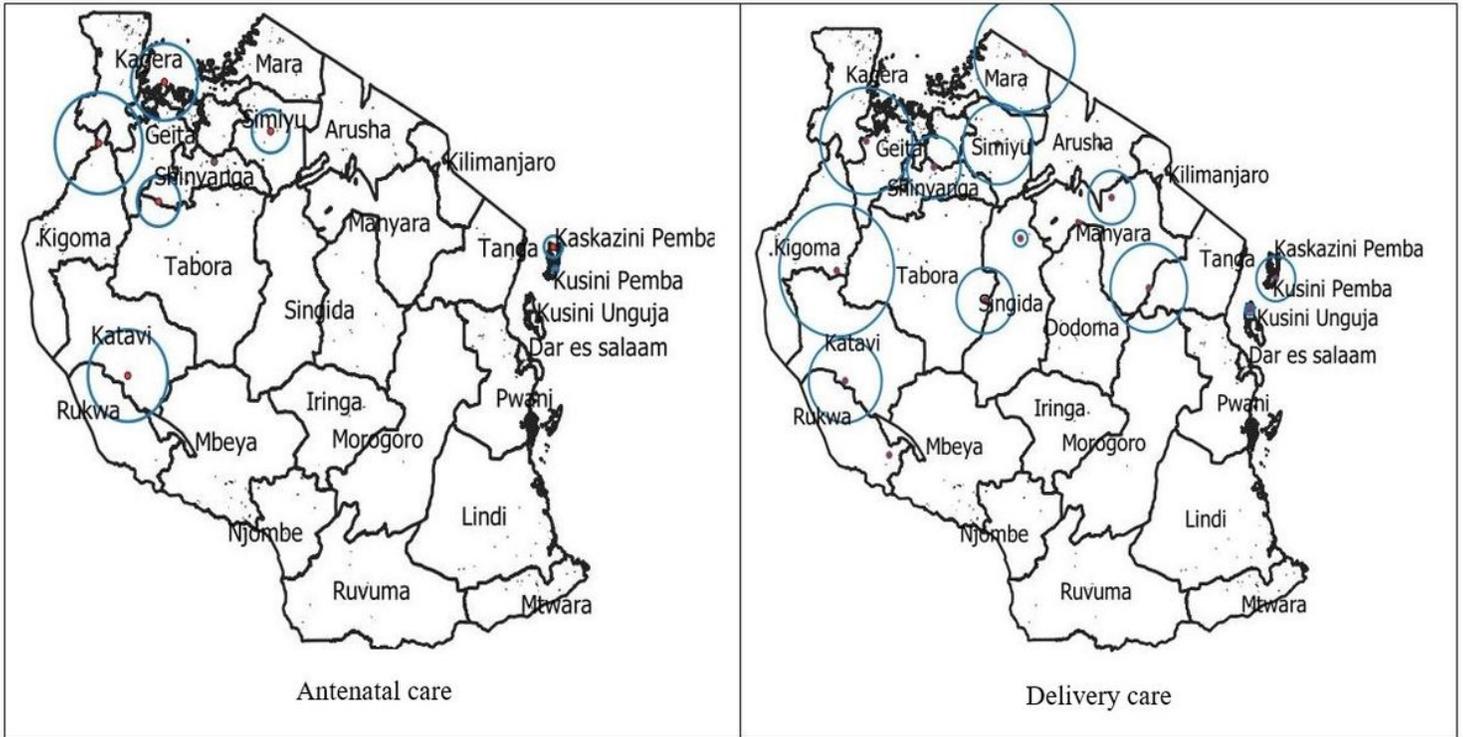


Figure 2

Clusters with the low utilization of antenatal care and delivery care from TDHS-MIS 2015-16 Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

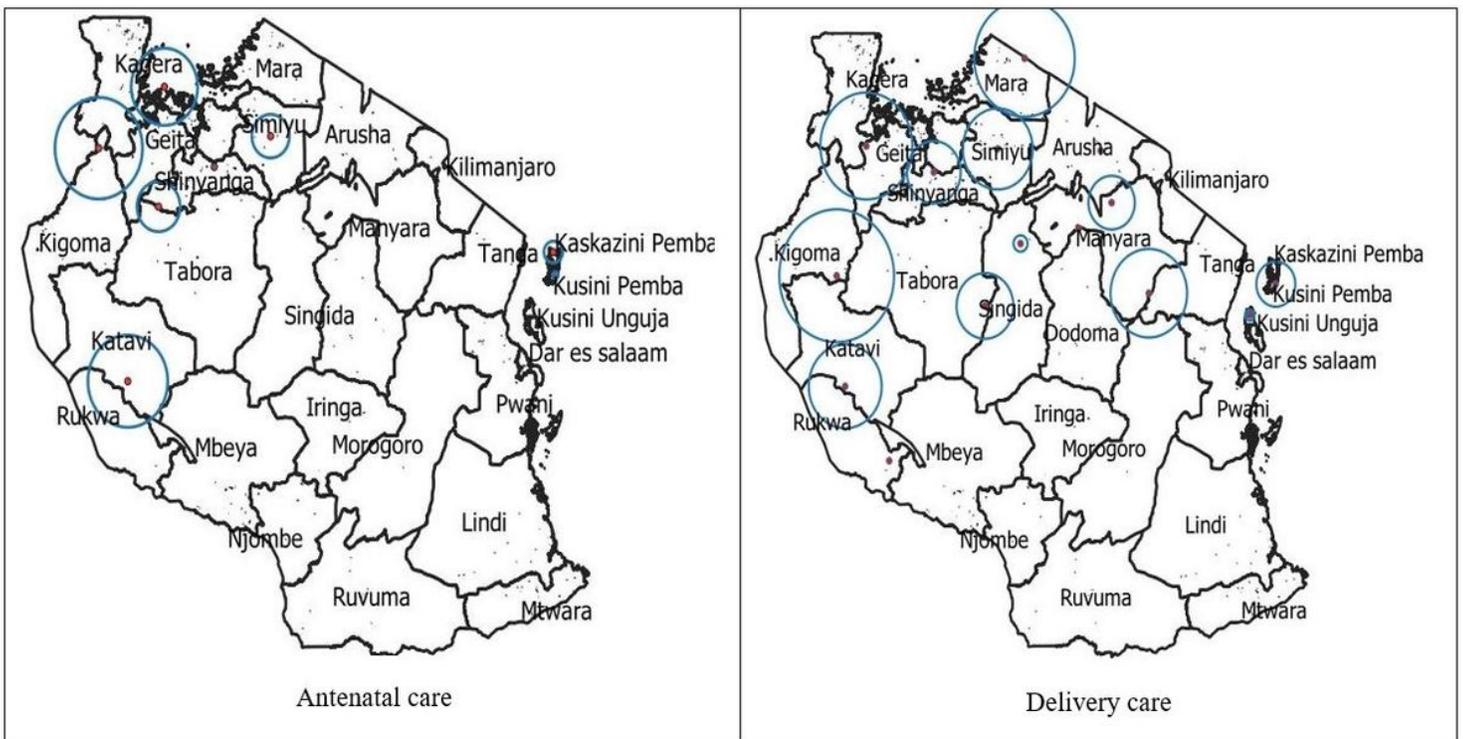


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