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RESEARCH ARTICLE

Assessment the Relationship of Maternal Child Health Accessibility, Infant Mortality and Fertility

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Abstract Equitable provision of health care services and full coverage of health accessibility are the major challenge for developing countries to achieved the sustainable development goal (SDG 3 and 10). A geographical information system (GIS) is an effective platform to knowing how much area and population is covered by the existing MCH (maternal child health) services network for better health care planning. The main aim of this study is to assess the geographical accessibility of MCH services and find out what kind of impact they give on infant mortality and fertility in an EAG district of India. Fot this puprpose, the study used primary as well as secondary data from various sources. This study used buffer zone analysis, service area analysis for MCH health accessibility with the help of geospatial technologies and then multiple regression analysis run for find out the relationship between MCH accessibility, infant moratality and fertility in the study area for uncover the answer. The findings highlights lower accessibility is prevailed in the study area in which 41 percent village was underserved by the buffer zone analysis while 62 percent was underserved by the service area analysis out of 2075 villages in the district. This study also find that health accessibility can explain 53 percent of the infant mortality and IMR may control 33 percent of the children ever born in the district. This study provided the fact that health accessibility increases the educational, health and economic prosperity which give a crucial impact on IMR and through IMR, it affect the fertility.

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1. Introduction

"*Good health is one of the most important ingredients for a happy and productive life. And yet, many people do not have access to health care and live in conditions that spread disease*" - *Robert Alan Silverstein*

Nearly 130 million of babies take their first breath in this world in each year. This moment make happy and joyful for the mothers and the people all around (Masoom, 2017). Each year nearly three million children die in their first month of life (Taylor, 2016); it's one of the darkest truths of the world. USAID child and maternal survival deputy coordinator, Taylor quoted that "Any Women need to able to access the care and services, she needed to ensure that her next pregnancy had a happier ending: a safe pregnancy, a successful delivery and a healthy baby".

Mother and child are two most vulnerable sections of the society (Akhtar and Izhar, 2010; Lule, et al. 2005; Boopathy et al. 2014; Taneja, 2015; Jeyalakshmi et al. 2011; Shekhar et al. 2010; Mondal, 2003), therefore they need proper food and nutrition and better health services. Women who give birth need essential care before and after, for ensuring healthy lives of both mother and child (Singh, 2014). Health and wellbeing are important factors for sustainable development goal (SDGs). Improved MCH services (maternal health care services) stimulate to produce good healthy human resource for future and reduced poverty by increasing income and also promote the gender equality (PRB, 2014).

Madhya Pradesh is one the EAG (Empowered Action Group)states of India where highest IMR (52 per 1000 infants birth) recorded (SRS, 2014), this was the worse condition than the least developed country of Africa like Namibia (45.64), Malawi (48.01) and Haiti (49.43) in the same year (CIA Factsheet, 2014). High MMR (227 per 0.1 million mother) was also recorded in the state (AHS 2012-13) which was almost equivalent to the countries of Gabon (230), Papua New Guinea (230) (CIA Factsheet 2014). Above significant facts proved that Madhya Pradesh state was very poorin MCH status.

Out of the 51 districts of Madhya Pradesh, Sagar is one of the backward district in the context of MCH services where IMR was 70 (AHS 2013) which was higher than the country's average of 42 and it is also higher than some of the very least developed African countries like South Sudan (68.16), Zambia (66.62) and Burundi (63.44). MMR in Sagar district had recorded 322 which was higher than Pakistan (260) and Bangladesh (240) and also compare to Uganda (310), Swaziland (320) and Rwanda (340), etc. According to the above mentioned facts it is clear that the development and extension of

MCH services are very poor in Sagar district of Madhya Pradesh.

Access to healthcare services is a multidimensional complex system, which includes availability and its geographic accessibility, and financial accessibility (Al-Taiar et al., 2010 and Blanford et al., 2012). On the other hand, efficiency of health centre has positive impact on MCH status and efficiency is based on performance of the human resource and proper utilization of fund (Som and Mishra, 2017). In India, MCH services are free of cost in public health centers that's why question of financial accessibility is not a major issue in the study area. On the other hand, spatial disparity of health centers and road accessibility has been long term concern of medical geographer (Joseph and Phillips, 1984 and Satia et al., 2013). The geographic location and allocation of health centers along the terrain pattern (Morphmetry), road connectivity with inhabitant and conditions and accessibility throughout the year are the key component in the utilization of maternal health care services (Fatih & EGRESI, 2013; Akhtar & Izhar, 2010 and Gage &Calixthe, 2006). Patients tend to use health facilities more if they are located closer to them than they are far away (Mizen, 2015). Low availability and accessibility of health centers and lack of road connectivity has stimulated the chance of home delivery which consequence increases of infant death.

The main objective of this study are (a)To analyse the scenario of maternal health care services. (b)To assess the impact of morphology, road connectivity and population pressure to access the MCH health services in Sagar district which is one of the more problematic districts of the country. (c)To Analysis the interrelationship of health accessibility, infant mortality and Fertility in the study region.

The relationship between health accessibility, infant mortality and fertility can be conceptualized at a fairly general level, depicted in fig. 1, Where a set of causal factors impact on health accessibility and it affect the intermediate variable infant mortality which turn determine the final outcome in terms of population fertility. It is recognized that infant mortality of an area depended on the level of health accessibility which they achieved through the institutional delivery and health services (Som and Mishra, 2016)

The parameters can be categorized into three groups:

- Health accessibility depends on the physiography condition (elevation) and slope surface of the area. High rugged relief and high slope is constrained on higher health accessibility.
- High health accessibility helps to timely received health services and institution delivery which reduced the chance of infant death.
- Infant mortality rate increase population fertility by having tendency to replace the dead child.

Some of the studies find out the relationship of morphometry of the surface and health accessibility (Kara &Egresi, 2012-13; and Gage &Calixthe, 2006) and some others studies health accessibility and infant mortality (Frankenberg, 1995; Gruber et. al., 2014 and Som and Mishra, 2016) while some others studies the relation between infant mortality and population fertility (Yamada,1985 and Kaplan et al., 2015). In this study include all the variables and find out the relationship between them which is not previously studied.

2.Methods

Main focus of this study is on MCH service centers because these units encompass a set of basic actions to solve the most serious problem of this region. For this analysis location of the MCH service centers obtained from HMIS –DCIR, Sagar, 2014-15 survey. Total 70 MCH centers includes in the study which are located in different parts of Sagar district of Madhya Pradesh. Total 900 reproductive age women also surveyed during 2016 December to 2017 February is used as a primary source with 99 percent confidence level and 4.3 percent confidence interval. This sample was collected by the stratified random sampling method. Household and women questionnaire was used to collect the demographic and socio-economic data. After that, 5 focus group discussion was conducted in each village for know the cause and consequence in depth.

A digital elevation model (DEM) of Sagar district prepared based on aster GDEM with 30 M of spatial resolution. Since, toposheets are old and do not have latest information regarding road network and location and extent of a village, therefore, a new map is prepared by using base map of the state government and Google road network. Administrative units divided into two tiers system i.e. community development block and the

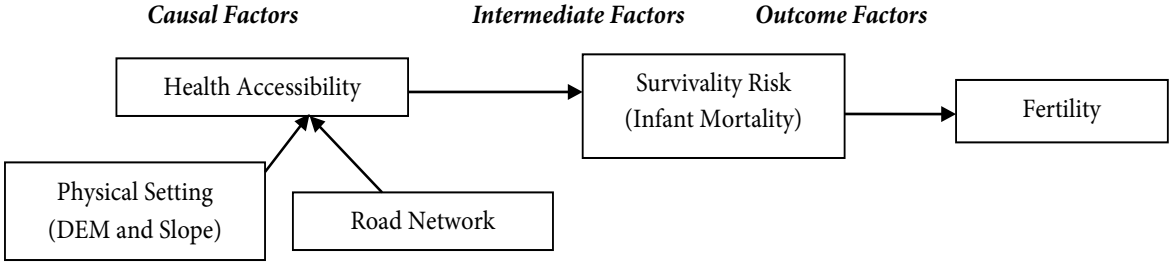

Figure 1. Conceptual Framework

Table 1. Walking and driving travel times on different road types in Sagar District

Road Type	Travel Time	
	Walking	Vehicle
National Highway	5km/h	60km/h
State Highway	5km/h	50km/h
District Road	5km/h	40km/h
Other Road	4km/h	30km/h

Source: estimated by the authors

Table 2. Type of Analysis Performed

Mapping Techniques		Statistical Analysis		(Demographic Techniques	
Mapping Techniques	Software used	Statistical Analysis	Software used	(Demographic Techniques	Software used
Digital Elevation Model	ARC GIS 10.1	Statistical Analysis	SPSS 17	Population Density	Ms. Excel
Slope Map		Descriptive Statistics		Infant Mortality (Survivality risk)	
Road network Map		Correlation Matrix		Population Fertility (Children ever born)	
Population Density Map		Multiple Regression Analysis			
Village Map					
Buffer Zone Analysis					
Service Area Analysis					

Source: Constructed by the authors

village. Road network classified in four categories, i.e. national high way (NH), state high way (SH), district roads and other roads. Different roads have different speed of driving capability of vehicles, on the basis of certain parameters duration of time estimated for reaching nearest MCH service centre by these roads (Table 1).

This study used mapping techniques, statistical techniques and demographic techniques with the help of sophisticated software such as SPSS 17, ARC GIS 10.1 andMs Excel (Table 2). Accessibility of MCH centers was measured by the buffer zone analysis and service area analysis. Buffer zone analysis of all MCH centers with the Government of India norms (2 Km for Sub center, 5 km for PHC and 10 km for CHC, SDH and DH). After that accessibility analysis conceded using the service area (SA) tool of network analysis extension from ARC GIS. Two types of travel time considered i.e. walking method and driving vehicles method. Following function used to calculate driving and walking time in minutes through the road network:

$$Service\ Area = \frac{Length\ of\ Roads}{Maximum\ speed\ (for\ each\ type\ of\ the\ road)} \times 30$$

Vector layer with lines (road network) and the DEMare used as input data. To assess the impact of morphology on health accessibility, a relative relief map prepared with help of DEM by using ARC GIS. The fields with estimated time in minutes in forward and reverse directions created with the default value of speed of 5km/hour.Local Sub centre and primary health center are not sufficient facility for a safe delivery.So, the people prefer delivery in nearer CHC's for general delivery case and for complicated case in Sagar district hospital. All season Road are not available in major rural areas. Ambulance is generally available in respondent home 45 to 60minutesapproxafter telephonic call. After arrival of the ambulance 30 minutes are threshold time for safe delivery. Otherwise, the problem is occurred and mostly case delivery in home or in road. That's why, Maximum travel time considered 30 minutes for a serve area. Areas more than 30 minutes away from MCH services area considered as an underserved area.

After that for find out the role of health accessibility, availability on IMR this study used multiple regression analysis and then regression analysis done for the role of IMR on fertility where fertility (MCEB) as a dependent variable with IMR as an independent variable.

3. Results and Discussion

Sagar district is situated in north central part of Madhya Pradesh state of India. The district has almost central location in the country, which lies between 23°10′-24°27′N and 78°4′-79°2′E. The tropic of cancer passes through the southern part of the district. The western, southern and eastern boundaries of this districts are formed by Guna, Vidisha and Raisen (in the west), Narsinghpur (in the south), Damoh (in the east) and Chhattarpur (in the north-east) districts of Madhya Pradesh. The largest extent of the district is along the south-east to north-east direction and is about 168.92 kms. while extreme southern part measures about 120.7 kms. Sagar, headquarter of revenue division and district, divided in eleven community development blocks viz. Sagar, Jaisinagar, Rahatgrah, Khurai, Bina, Malthone, Banda, Rehli, Deori, Shahgrah and Kesli.

Geomorphologically, this district lies at the south-eastern edge of the Malwa region. It lies to the north of Narmada River and is actually separated from its valley by a steep escarpment. The drainage of the district is directed towards the north and north east and is under Ganga-Yamuna drainage system.

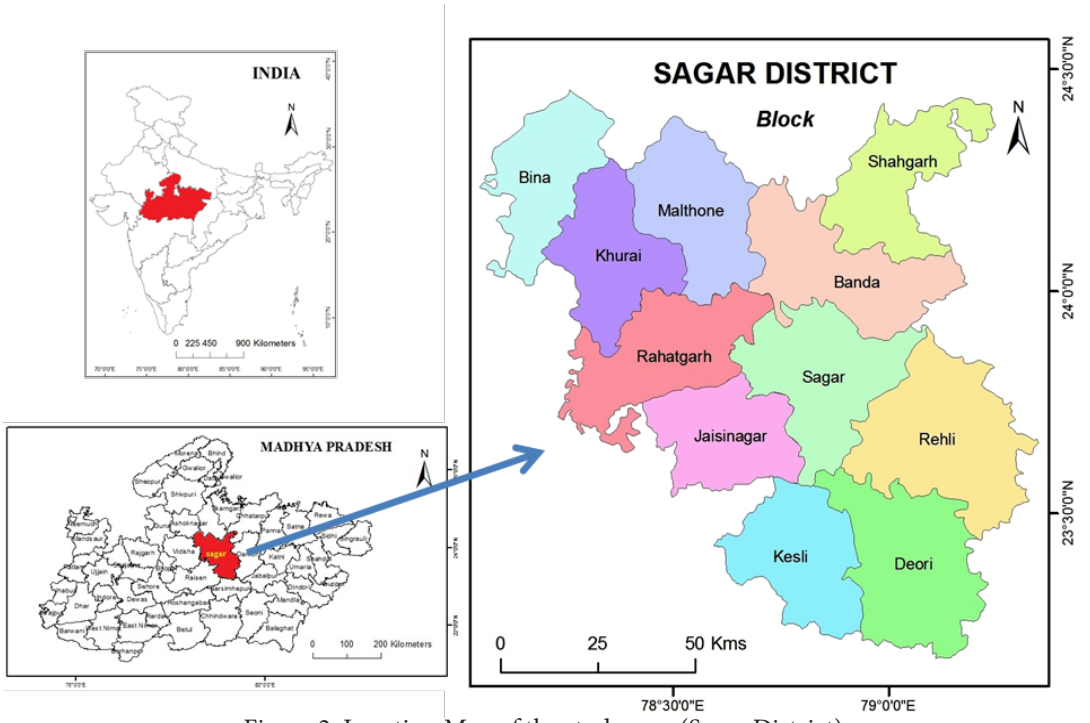

Figure 2. Location Map of the study area (Sagar District)

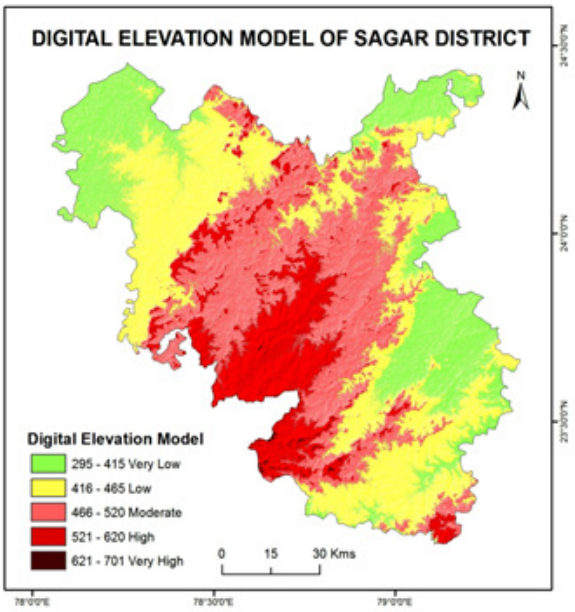

Figure 3. Digital Elevation Model of Sagar District

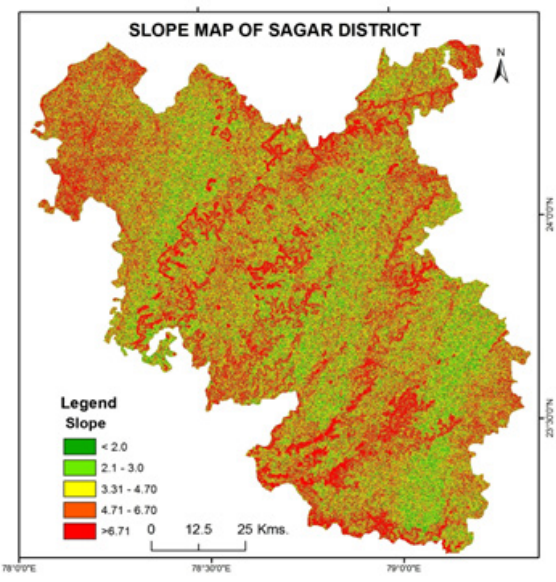

Figure 4. Slope Map of Sagar District

Sagar lies in an extensive plain broken by low, forested hills and watered by SunarRiver. The highest relief of the district, situated in the west-central part (Kesli and Jasinagar Block) towards north-western side (Bina-Khurai plain) from 701 meter to 295 meter.

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The district is accessible by railways and roadways. Sagar city lies on Bina-Katni section of the west central railway. NH 26A is entered from Sironj via Jaruakhera and NH 26 entered from Lalitpur via Sagar towards Narsimhapur. NH 34 is entered from Chhatarpur via Sagar and Rahatgarh then divided in to two parts one towards Vidisha and another towards Begamganj.

According to the HMIS-DICR (2014-15), Sagar district has total 294 health centre while only 65 (22.11 %) health centers haveprovided mother and child health services. Banda block has very low number while Malthone has the highest number of MCH service centers. Sagar block has a district hospital and Khurai also a sub-divisional hospital which has wide area coverage than other units of the district (Table 3).

MCH services and accessibility of the people residing within the boundaries of the Sagar district are closely associated with each other. Accessibility has its prime significance while determining the MCH services in the study area, as the area has undulating terrain and there are some areas which are covered by dense forests. There are some small rivers which do not have overpass and make trouble during the rainy season.

Analysis proximity of the residential area to MCH service centre in the Sagar district identified by creating buffer zone around the health centre. According to government rules, buffer around the MCH service centre divided on the basis of the health centre level i.e. 2 km for sub-centre, 5 km for the primary health centre and 10 for community health centre, sub-divisional hospital and district hospital.

Bina, Khurai, Sagar and Rehli blocks have high agglomeration of MCH service centers of the district because they have comparatively high population density. This high agglomeration area covers 6257.43 km2which is 61.04% of Sagar district where total geographical area is 10252 km2. MCH services also come under the category of emergency services that need urgency in treatment that's why accessibility becomes necessity for residents. Around 3 km buffer from the service centre is good for urgent need of the patients for medical intervention. On the consideration of the above fact, total 65 MCH service centers of the district have covered 1838.57 km2 area i.e.17.93% of 10252 km2 of the district.

Length of road per km2 is one of the traditional indexes of road density. Road density indicates the accessibility of the area. At block level, Rahatgarh (0.49) has highest road density while Rehli (0.41) and Shahgarh (0.41) have very low road density. Central region of the district has comparatively high road density than the southern and northern region. In the case of NH and SH, Sagar block has high road density and 6 blocks (Deori, Jasinagar, Khurai, Malthone,

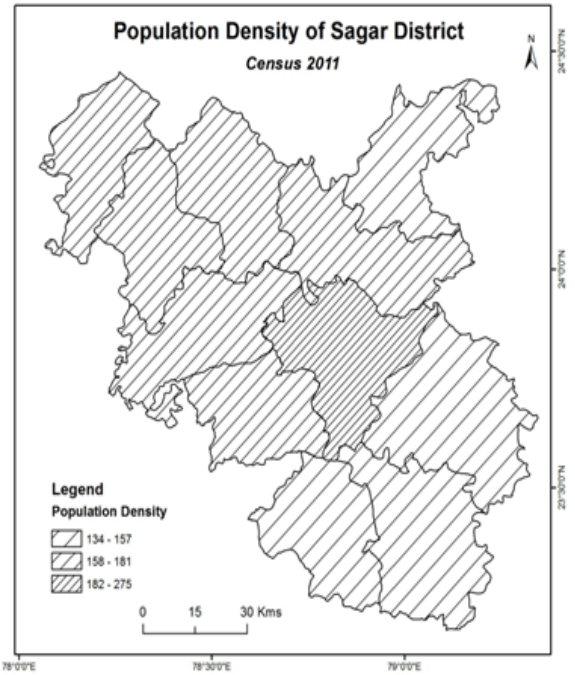

Figure 5. Population Density Map of Sagar District

Table 3. Mother and Child Health Service Centers in Sagar District

	MCH FACILITIES				
Block	Total HC	Level 1	Level 2	Level 3	Total MCH Centre
Banda	27	1	1		2
Bina	25	4	2	1	7
Deori	26	4	1	1	6
Jasinagar	25	3	2		5
Kesli	24	4	2		6
Khurai	24	2	1	1	4
Malthone	24	8	2		10
Rahatgarh	29	4	2		6
Rehli	32	5	2		7
Sagar	38	3	3	1	7
Shahgarh	19	3	2		5
Total	293	41	20	4	65

Source: estimated by the authors

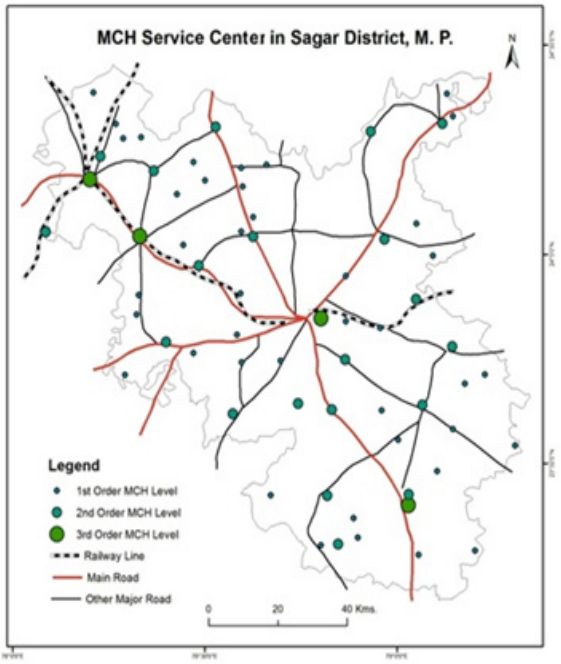

Figure 6. MCH service Centers in Sagar District

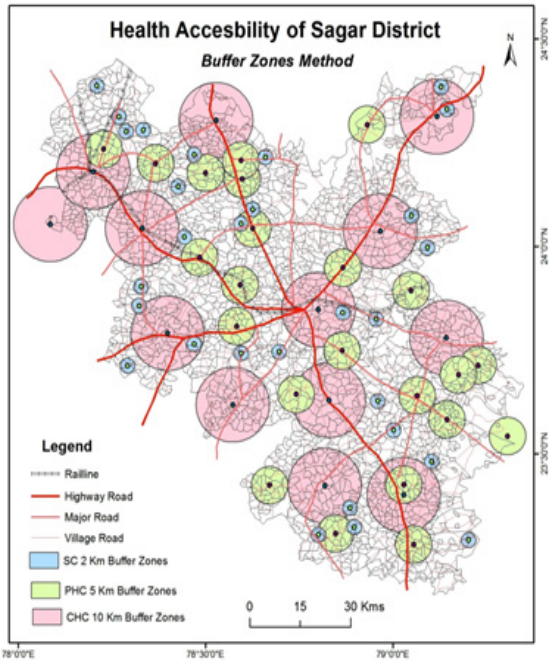

Figure 7. Health Accessibility of Sagar District (Buffer Zone Analysis)

Table 4. Road Length on different road types and Road Density, Sagar District

Block	NH Length	SH Length	MDR Length	Other Roads Length	Total Road Length	Length of road per Sq km. Area
Banda	0.000	0.000	0.000	485.050	485.050	0.48
Bina	0.000	0.000	84.400	239.780	324.180	0.44
Deori	65.000	0.000	48.800	364.060	477.860	0.42
Jasinagar	0.000	32.000	23.000	298.350	353.350	0.47
Kesli	0.000	0.000	53.800	306.100	359.900	0.43
Khurai	0.000	61.000	55.500	269.600	386.100	0.48
Malthone	46.000	14.000	18.000	326.250	404.250	0.45
Rahatgarh	0.000	11.800	0.000	472.430	484.230	0.49
Rehli	0.000	33.000	91.700	388.150	512.850	0.41
Sagar	65.400	55.000	39.000	288.970	448.370	0.43
Shahgar	0.000	0.000	0.000	339.890	339.890	0.41
Total	176.400	206.800	414.200	3,778.630	4,576.030	0.45

Source: Calculated based on PMGSY (core network , 2017)

Rahatgarh and Rehli) have also accessibility through SH and NH (Table 4).

Habitat connect with health centre by the road indicates the accessibility of health services which resulted in the health status outcome of that area. In Sagar district, 1337 habitats have connected by the road out of 1884 habitats i.e. 70.97 percent of the district habitats. At block level, Deori block (51.93%) has least number of habitat cover while Rehli (88.74%) has highest number of habitat coverage block. Six blocks have lower habitat coverage than the district average while five blocks are in higher category (Table 5).

Thirty minutes driving time have mostly covered the area of Sagar and Khurai block while lowest in the Malthone block (Table 6). 1420 (69 percent) out of the 2075village is connected by the road network coverage in the district.

On the basis of the above analysis the main problematic regions in the study area are-

Institute delivery and postnatal care within 48 hours is the outcome of health Accessibility. This variable has determined 53.18 percent IMR in the district with 0.001 significance levels. This study suggests that post neo natal care and institutional delivery can control the high IMR and MMR (Table 8).

Table 5. Habitat coverage by the Road in Sagar District

Habitation Coverage							
Block	No of Habitat	Habitat Connected	% of Habitation Coverage	Block	No of Habitat	Habitat Connected	% of Habitation Coverage
Banda	146	117	80.14	Malthone	175	115	65.71
Bina	154	115	74.68	Rahatgarh	199	132	66.33
Deori	233	121	51.93	Rehli	222	197	88.74
Jasinagar	146	98	67.12	Sagar	151	116	76.82
Kesli	172	125	72.67	Shahgar	109	76	69.72
Khurai	177	125	70.62	Total	1,884	1,337	70.97

Source: Calculated based on PMGSY (core network , 2017)

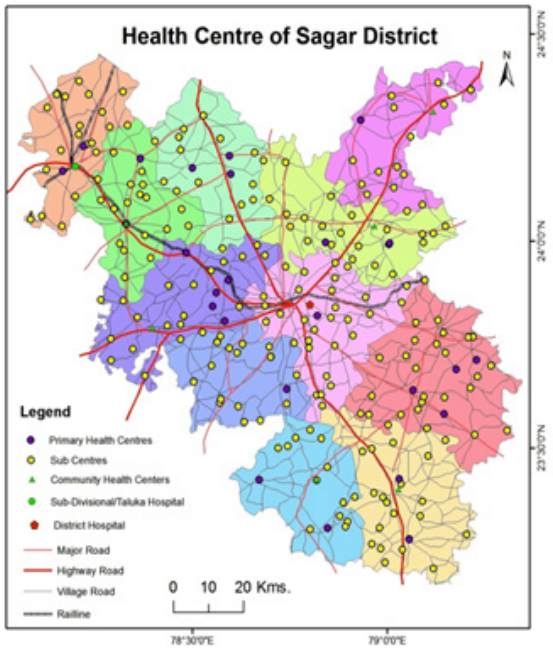

Figure 8. Health center with Road Network in Sagar District

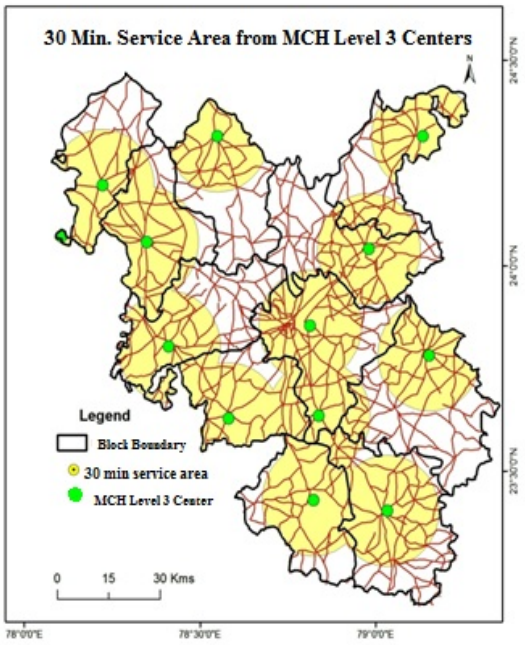

Figure 9. 30 Minute service Area from MCH Level 3 center in Sagar District

Table 6. Health Accessibility at Block Level in Sagar District

NAME OF BLOCK	NO OF VILLAGE	ACCESSIBLE VILLAGE
Banda	179	97 (54%)
Bina	177	133 (75%)
Deori	255	199 (78%)
Jasinagar	149	121 (81%)
Kesli	189	146 (77%)
Khurai	187	161 (86%)
Malthone	193	79 (41%)
Rahatgarh	202	119 (59%)
Rehli	246	138 (56%)
Sagar	170	155 (91%)
Shahgarh	128	86 (67%)
Total	2075	1420 (69%)

Source: Calculated by the authors

Table 7. Problematic Region with Causes

Problematic Region	Causes
Northern Portion of Banda	Mostly road are seasonal and location of MCH service centre
Southern Portion of Malthone	Lower habitation coverage (65%) and undulation terrain and comparatively high slope
Eastern Portion of Rahatgarh	Lower habitation coverage (66%) and undulation terrain and comparatively high slope
Western Portion of Sahagarh	Western high slope and undulation land and lower road connectivity

Table 8. Health Accessibility and Availability- (IMR)

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	90.14591	15.378848	5.862	1.06e-06***
PNCw48h	-0.16452	0.242595	-0.678	0.5020 *
Institute Delivery	0.212134	0.610611	0.347	0.7303***
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				
Multiple R-squared: 0.6321, Adjusted R-squared 0.5318 p-value: 0.001047				

Source: Calculated by the authors

Table 9. Relationship of Infant Mortality and Children Ever Born

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	2.19008	0.05128	42.71	<2e-16 ***
Infant Mortality	1.37389	0.06560	20.95	<2e-16 ***
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				
DF: 898, Multiple R-squared: : 0.3282, Adjusted R-squared 0.3274, p-value: < 2.2e-16				

Source: Calculated by Authors from field survey 2015-16.

Infant mortality and child ever born has a positive relationship seen in the study area. Infant mortality can be controlled 32.74 percent of child ever born in the study area (Table 9). Higher the number of infant mortality increases the number of child ever born by the thinking of death replacement to fulfill their family size.

Health accessibility hasincreased the opportunity to achieve the education and economic prosperity. Girl child level of education increases when they have school and college nearer to their residence. This education and economic prosperity increases awareness about child nutrition and health to reducing IMR and MCEB.

4. Conclusion

Morphology, location of the Health centre and Road network play a crucial role for higher accessibility of MCH service. Sagar and Bina block are highly accessible with consequence they have high MCH status while Banda and Malthone are very low level accessible with output of low MCH status. According to GOI norms, Buffer zone of 65 MCH service center covers 51 percent (1058 village) village out of 2075 villagesin Sagar district which is great concern for universal health coverage (SDG-3). Health accessibility explains 53 percent of the IMR of the district. So, serious attention on this problem will helpful for Sagar to reach IMR below the country average (42). IMR may control 33 percent of the children ever born in the district. This study provided the fact that health accessibility increases the educational, health and economic prosperity which give a crucial impact on IMR and through IMR, it affect the fertility. This study is one of the first of its kind in Madhya Pradesh, which can be replicated to examine other health programmes not only within the state of Madhya Pradesh but also across the states of India.

Morphological constrain are natural phenomena. So recommendation of solving problem on the basis of improving road network and establish the new MCH center. One community health centre (MCH level 3) need to be establish in the conjunction region of Banda, Malthone, Rahatgarh and Sahagarh Block. Improving Habitation coverage by the road network with MCH center in the Malthoneand RahatgarhC. D. Block.

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