

Epidemiological Trend of Malaria Cases in India: A Statistical Analysis.

Running Title: Epidemiological Trend of Malaria Cases in India

Abstract

This study **explain** the state-wise patterns of transmissibility of prevalence of malaria epidemic in India, using yearly time series data for the period 2001 to 2013. The data for the study was obtained from different reports of National Vector Borne Disease Control Programme (NVBDCP), Ministry of Health and Family Welfare, Government of India. The time series data was initially analyzed by using the Confidence Interval and Chi square tests. We have also used the ANOVA and a post hoc Tukey HSD tests to analyze the geographical differences between means of prevalence rate of malaria.

The result of the study reveals that prevalence rate of malaria shows a decreasing trend for the study period from 2001 to 2013 in India. Further, ANOVA test has shown a significant difference between the prevalence rates of malaria across different states in India, **even though a decreasing trend was noted over the study period from 2008 -2013**. Also eight homogenous subgroups were formed by using post hoc Tukey HSD test, in which four states viz. Mizoram, D & N Haveli, Arunachal Pradesh and Meghalaya had the highest prevalence of malaria as compared to other states of India; Delhi, Bihar, Himachal Pradesh, Kerala, Jammu & Kashmir, Lakshadweep, Sikkim, Punjab, Puducherry and Uttarakhand had the lowest prevalence rate. The results of this study can be of critical importance as different authors attempt to explore novel approaches to investigate the geographic variation in disease occurrence.

Keywords: Prevalence rate of Malaria, ANOVA tests, Tukey HSD tests and topography.

24 Introduction

25 Malaria is a life-threatening disease caused by **parasites** that are transmitted to people
 26 through the bites of infected **mosquitoes**. Approximately half of the world's population is at
 27 risk of malaria. Most malaria cases and deaths occur in sub-Saharan Africa. However, Asia,
 28 Latin America, and to a lesser extent the Middle East and parts of Europe are also affected. In
 29 2014, 97 countries and territories had ongoing malaria transmission. According to the latest
 30 estimates, released in December 2014, there were about 198 million cases of malaria in 2013
 31 and an estimated 584 000 deaths [1].

32 In the South East Asia Region approximately 337 million **population** are at moderate
 33 to high risk of Malaria [2]. According to the World Malaria report 2014, it is estimated that
 34 the number of confirmed malaria cases reported in the **SEARO** region decreased from 2.9 to
 35 1.5 million between 2000 and 2013. Three countries accounted for 97% of cases in 2013:
 36 India (55%), Myanmar (21%) and Indonesia (21%) [3].

37 In India, about 95% population resides in malaria endemic areas and 80% of malaria
 38 reported in the country is confined to areas consisting 20% of population residing in tribal,
 39 hilly, difficult and inaccessible areas [4]. During 2011, the malaria incidence was around
 40 1.31 million cases, 0.67 million **Pf** cases and 754 deaths; while during 2012, 1.01 million
 41 cases, 0.53 Pf cases and 519 deaths were reported. About 91% of malaria cases and 99% of
 42 deaths due to malaria are reported from high disease burden states namely Northeastern (NE)
 43 States, Andhra Pradesh, Chhattisgarh, Gujarat, Jharkhand, Karnataka, Madhya Pradesh,
 44 Maharashtra, Orissa, Rajasthan and West Bengal. However, other states are also vulnerable
 45 and have local and focal upsurge [5].

Extensive literature search looking at trend of Malaria prevalence revealed limited number studies being conducted in India, hence, evidence has been gathered from the studies done mainly in the in African region. A ten year trend analysis of malaria prevalence in Kola Diba, North Gondar, Northwest Ethiopia conducted by Alemu et al (2012) noted that the highest peak of malaria cases was during spring seasons of the year [6]. Hay et al (2004) used geographic information systems in combination with historical maps to quantify the anthropogenic impact on the distribution of malaria in the 20th century at six intervals between 1900 and 2002. Stratifying the present day malaria extent by endemicity class and examining regional differences highlighted that nearly 1 billion people are exposed to hypoendemic and mesoendemic malaria in Southeast Asia [7].

A retrospective analysis of burden of malaria in India conducted by Ashwani Kumar et al (2007) showed that disability adjusted life years lost due to malaria were 1.86 million years and Cost–benefit analysis suggested that every Rupee invested by the National Malaria Control Program paid a rich dividend of 19.7 Rupees [8]. Hence effective implementation of the preventive strategies can bring the burden not only in-terms of the prevalence of Malaria but also the costs involved in the programme. Evidence from scientific literature regarding the trend of malaria burden remains lacking in India. Hence the present study attempts to add to existing body of knowledge of Malaria, its trend and possible methods of trend analysis in India.

Method and Materials

This study was carried out by using secondary data of Malaria cases and deaths across different States of India. Thirteen year (2001 – 2013) malaria cases data was obtained from successive annual reports of National Vector Borne Disease Control Programme (NVBDCP), Ministry of Health and family welfare, Government of India and the data of total population of

India and the states was obtained from National Commission on Population, Ministry of Health and Family Welfare [5,9]. This study examined records of 2,07,28,060 malaria cases registered over thirteen years (2001 – 2013) in India. The data present in the electronic format was abstracted from the Microsoft Excel database and imported into SPSS statistical software and analysed using different statistical methods such as confidence interval, Chi-Square and Analysis of Variance (ANOVA).

Results and Discussion

Malaria is a huge public health problem in terms of morbidity and burden on health care facilities in India.⁵ In the present study fluctuating trend of Malaria was observed during study period of 2001-2013. A total of 2,072,8060 confirmed cases of Malaria were reported India. Cases of Malaria were found to be decreasing within the study period and very less number of cases reported (8,36,916) in 2013; highest number of cases (20,85,484) being reported in 2001. Out of these total 2,072,8060 confirmed malaria cases, 12,760 persons died during the study period, with a mean 981. In the present study we also observed a fluctuating trend of deaths of malaria cases within the study with the minimum (359) in 2013 and maximum (1,707) in 2006 (Figure 1). The proportion of *P. vivax* and *P. falciparum* varied in different parts of India. The increasing trend of total malaria cases was seen mainly due to an increase of *P. falciparum* with a minor contribution of *P. vivax*.

Table 1 shows that the prevalence rate of malaria decreased from 0.2027 % (CL 0.2024 – 0.2030) in 2001 to 0.0684 % (CL 0.0683 – 0.0685) in 2013. A decreasing trend was noted from 0.2027% (CL 0.2024 – 0.2030) in 2001 to 0.1760 % (CL 0.1757 – 0.1762) in 2003 with a slight increase in 2004 where it was increased to 0.1775 % (CL 0.1772 – 0.1777). Further, from 2005 onwards it gradually decreased from 0.1658 (CL 0.1655 – 0.1660) to 0.0684 % (CL 0.0683 –

0.0685) in 2013 (Table 1). The same trend was observed in two Indian studies [10, 11]. Also the year-wise deaths due to malaria was tested by using the Chi-square tests and the results show that there was a significant difference between number of deaths and survivors in India.

State-wise Distribution of Malaria Cases in India

The state-wise prevalence rate of malaria cases is shown in Figure 2. It demonstrates that six states viz. Meghalaya, Arunachal Pradesh, D & N Haveli, Mizoram and Orissa are having more percentage of malaria cases than others in India. Further it is observed that in almost all the states the prevalence rate of malaria was decreasing for the study period.

In order to carry out deeper analysis of the preceding results and derive more meaningful conclusion further, we intended to study the state-wise prevalence rate of malaria. The one-way ANOVA was applied to verify whether the prevalence rate of malaria was unequally distributed between the states. Before applying the One-way ANOVA, we needed to test the assumptions underlying the one-way ANOVA. There are three assumptions i.e. independence, normality and homogeneity. In this study the assumption of independence and normality were satisfied, since the testing centers of states were independent of each other, but the assumption of homogeneity of variance was not satisfied. If a statistical procedure is minutely affected by violating an assumption, the procedure is said to be robust with respect to that assumption. The One-way ANOVA is robust with respect to violations of the assumptions, except in the case of unequal variances with unequal sample sizes. That is, the ANOVA can be used when variances are only approximately equal if the number of subjects in each group is equal and since we have equal sample sizes for all the groups we can assume that variances are approximately equal and proceed with one-way ANOVA [12].

The results of one way ANOVA show that there was significant variation in mean prevalence rate of malaria between the states of India (Table 2), but it does not identify that which specific group of states are significantly different from each other. One way to further examine group differences is to use post-hoc or a posterior multiple comparison tests. In this study we have used Tukey HSD test to identify which specific group of states are significantly different from each other. The Table 3 shows the eight homogeneous subsets generated by SPSS using Tukey HSD post-hoc test. The subgroups of states were arranged from lower to higher prevalence rate of malaria.

First subgroup of homogeneous subsets of states of India generated by using SPSS consists of the states and union territories with low prevalence rate of malaria i.e., Delhi, Bihar, Himachal Pradesh, Kerala, Jammu & Kashmir, Lakshadweep, Sikkim, Punjab, Puducherry and Uttarakhand. Next homogenous subset consists of the states which have slightly high prevalence rate of malaria i.e. Chandigarh, Manipur, Tamil Nadu, Uttar Pradesh, Andhra Pradesh and third group which have next highest prevalence rate of malaria consists four states i.e. Karnataka, Rajasthan and Maharashtra and Daman & Diu. Next homogeneous subgroup consist seven states i.e., West Bengal, Haryana, Gujarat, Madhya Pradesh, Assam, Nagaland and Goa which have moderate prevalence rate of malaria. Fifth and seventh homogeneous subgroup consist only one state each i.e Tripura in fifth and Orissa in seventh subgroup. Sixth homogenous subgroup consists of only three states i.e Chhattisgarh, Jharkhand and A & N Islands which have third highest rate of prevalence. Finally the last homogenous subgroup of states which have highest rate of prevalence of malaria consists four states i.e. Mizoram, D & N Haveli, Arunachal Pradesh

and Meghalaya. It has also been noted that rainfall is comparatively high in these above mentioned states with high prevalence of malaria. Substantiating evidence has been obtained by a study conducted by Karema et al (2012) in Rwanda in district hospitals where rainfall and temperature remained favourable for malaria transmission [13]. The situation of malaria epidemic in India is clearly shown in India map (Figure 3).

Conclusion

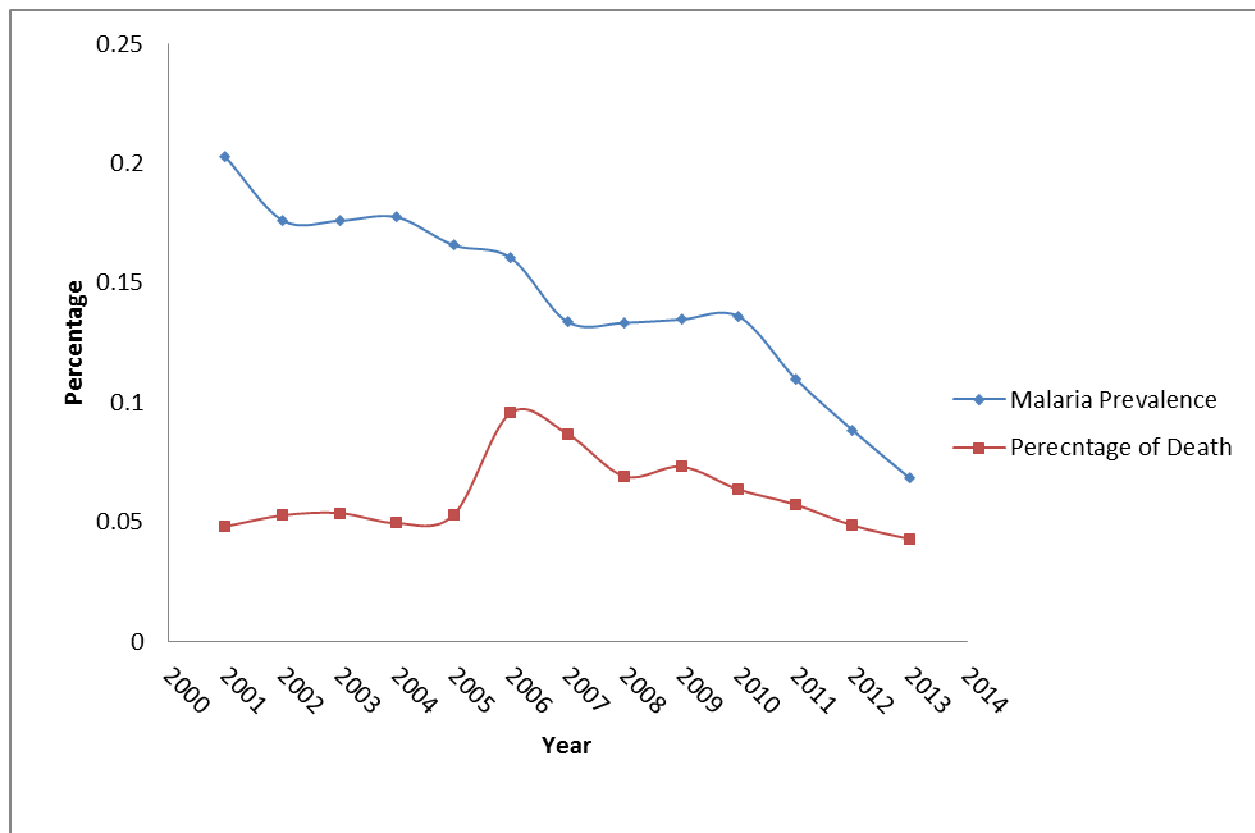
This study has explored the geographical patterns of transmissibility of malaria in India, using time series data, made available by reports of National Vector Borne Disease Control Programme (NVBDCP), Ministry of Health and Family Welfare, Government of India. The study indicates the rate of prevalence of malaria was decreasing during the study period. The result also reveals that there is significant difference between number of deaths and survival over a period of time.

Further we observed that there is significant difference between the transmissibility of prevalence rate of malaria across the geographical areas, even though the rate of prevalence of malaria shown decreasing trend over the study period. Finally the results of the study concluded that in four states viz. Mizoram, D & N Haveli, Arunachal Pradesh and Meghalaya are the highest rate prevalence of malaria as compared to other states of India. Rainfall in these states is comparatively more than other states of India which provides an ideal ground for breeding places for anopheline mosquito; hence programme implementation should give more focus to control the transmissibility malaria in these states.

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194 Figure 1 Trend of malaria prevalence and percentage of death due to malaria, India, 2001 - 2013.

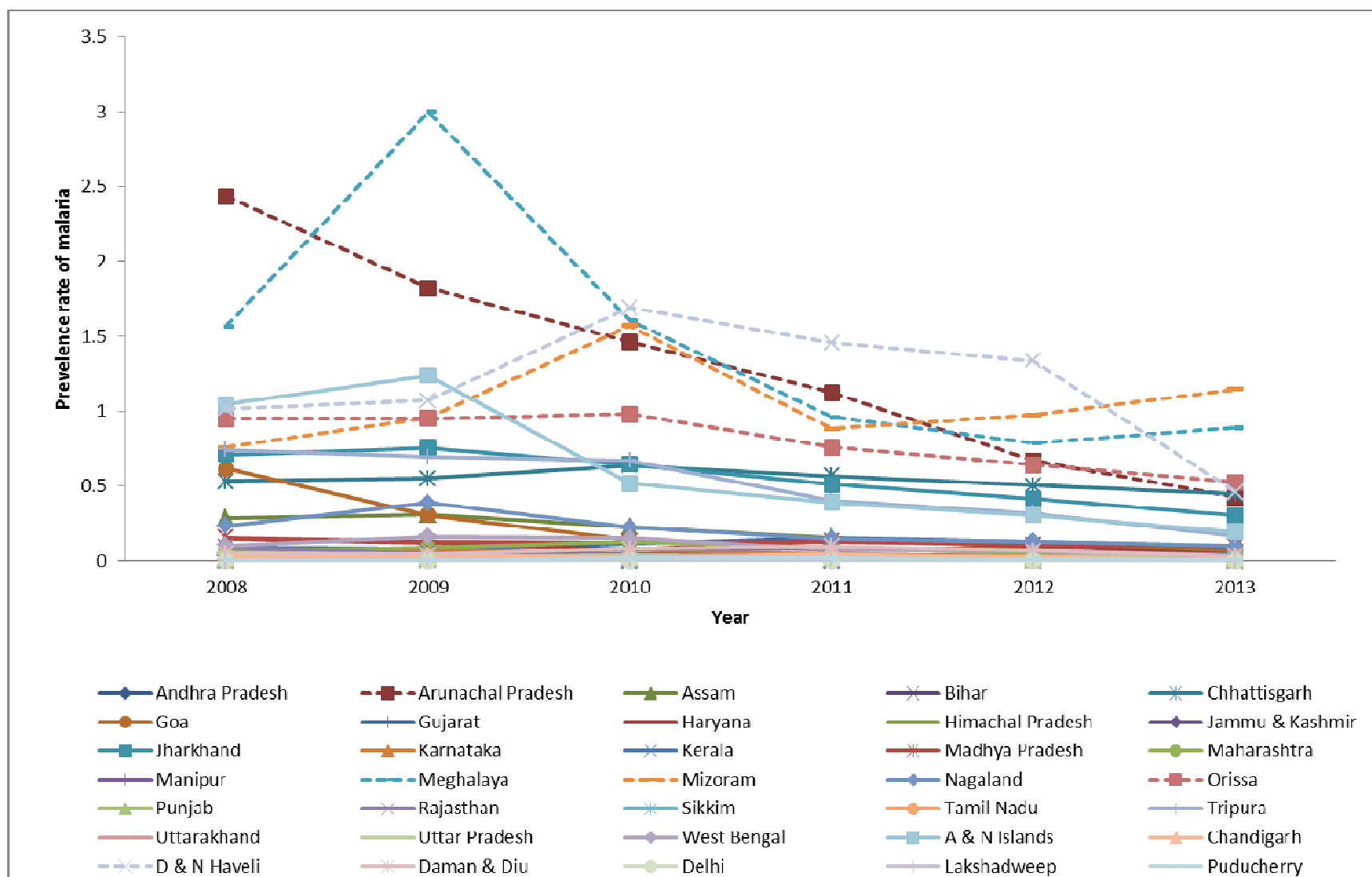


Figure 2: State-wise distribution of prevalence rate of malaria in India from 2008-2013

197 Table 1: Year-wise distribution of prevalence rate of Malaria in India for the period 2001 to 2013

Year	Total population	Number of Malaria Cases	Prevalence rate of malaria	95% CL
2001	1028737436	2085484	0.2027	(0.2024-0.2030)
2002	1045547000	1842019	0.1762	(0.1759-0.1764)
2003	1062388000	1869403	0.1760	(0.1757-0.1762)
2004	1079117000	1915363	0.1775	(0.1772-0.1777)
2005	1095722000	1816569	0.1658	(0.1655-0.1660)
2006	1112186000	1785129	0.1605	(0.1603-0.1607)
2007	1128521000	1508927	0.1337	(0.1335-0.1339)
2008	1144734000	1526210	0.1333	(0.1331-0.1335)
2009	1160813000	1563574	0.1347	(0.1345-0.1349)
2010	1176742000	1599986	0.1360	(0.1358-0.1362)
2011	1192506000	1310656	0.1099	(0.1097-0.1101)
2012	1208116000	1067824	0.0884	(0.0882-0.0886)
2013	1223581000	836916	0.0684	(0.0683-0.0685)

198

199 Table 2: Results of One-Way ANOVA

	Sum of Squares	df	Mean Square	F	P value
Between Groups	35.037	34	1.031	19.075	0.000
Within Groups	9.454	175	0.054		
Total	44.491	209			

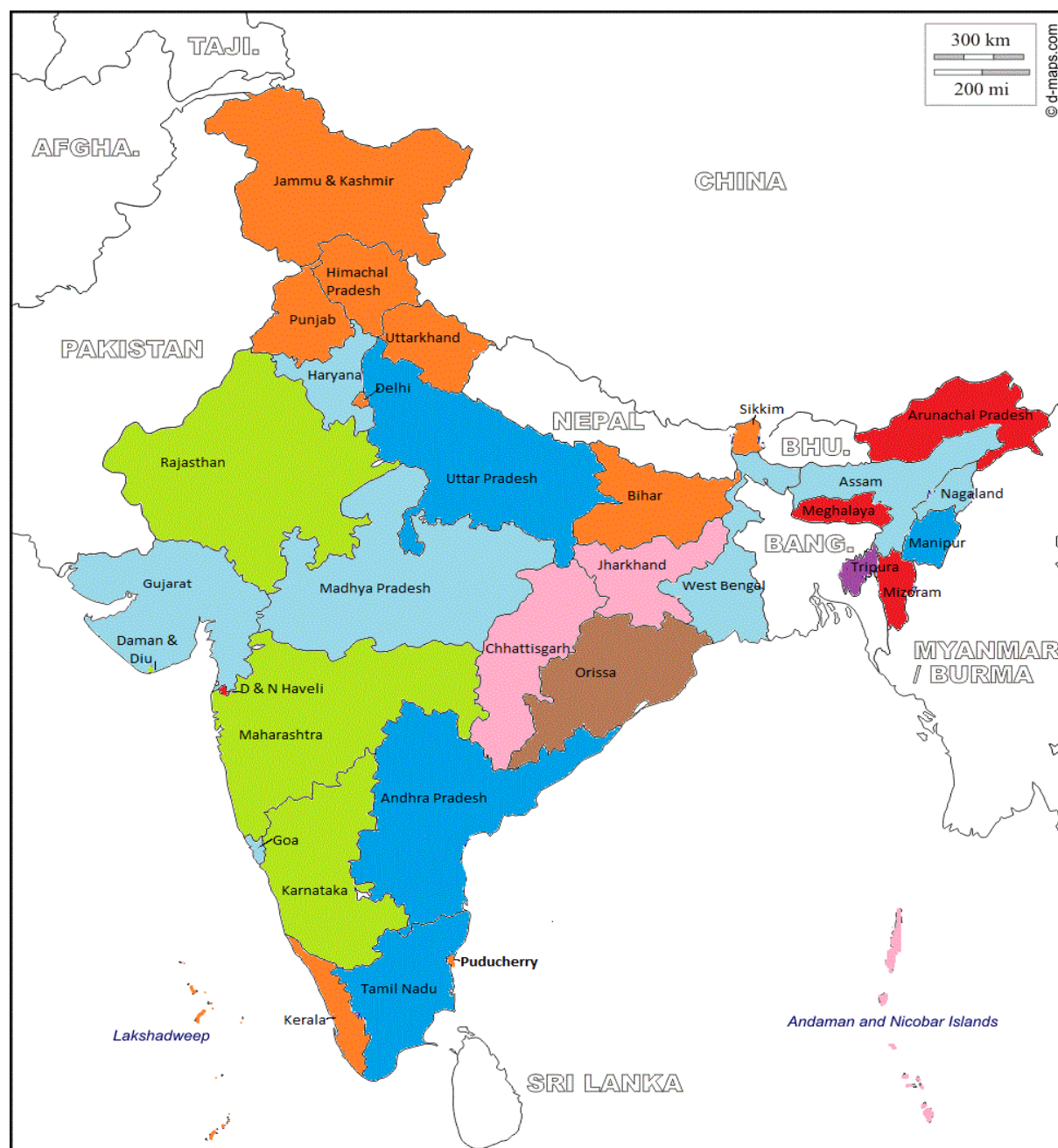
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Table 3: The homogeneous subsets generated by using Tukey HSD Post Hoc test

Stats	N	Subset for alpha = 0.05							
		1	2	3	4	5	6	7	8
Delhi	6	.0017							
Bihar	6	.0026							
Himachal Pradesh	6	.0028							
Kerala	6	.0057							
Jammu & Kashmir	6	.0057							
Lakshadweep	6	.0068							
Sikkim	6	.0081							
Punjab	6	.0091							
Puducherry	6	.0094							
Uttarakhand	6	.0146							
Chandigarh	6		.0251						
Manipur	6		.0263						
Tamil Nadu	6		.0271						
Uttar Pradesh	6		.0309						
Andhra Pradesh	6		.0319						
Karnataka	6			.0515					
Daman & Diu	6			.0601					
Rajasthan	6			.0664					
Maharashtra	6			.0747					
West Bengal	6				.0970				
Haryana	6				.1043				
Gujarat	6				.1093				
Madhya Pradesh	6				.1218				
Assam	6				.1893				
Nagaland	6				.2032				
Goa	6				.2171				
Tripura	6					.4977			
Chhattisgarh	6						.5382		
Jharkhand	6						.5551		
A & N Islands	6						.6142		
Orissa	6							.7997	
Mizoram	6								1.0481
D & N Haveli	6								1.1713
Arunachal Pradesh	6								1.3222
Meghalaya	6								1.4677
Sig.		.091	.062	.077	.056	.943	.067	.648	.368

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- - Mean prevalence rate of malaria between 0.002 to 0.020 .
- - Mean prevalence rate of malaria between 0.026 to 0.032 .
- - Mean prevalence rate of malaria between 0.052 to 0.075 .
- - Mean prevalence rate of malaria between 0.098 to 0.22 .
- - Mean prevalence rate of malaria 0.497 .
- - Mean prevalence rate of malaria between 0.53 to 0.62 .
- - Mean prevalence rate of malaria is 0.799 .
- - Mean prevalence rate of malaria between 0.10 to 1.5 .

Figure 3. Malaria Epidemic situation in India.