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RESEARCH ARTICLE

HIV/AIDS EPIDEMIC IN GOA, INDIA: SPATIAL PATTERNS IN TRANSMISSIBILITY

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ABSTRACT

This study explores the geographical and demographic patterns of transmissibility of HIV/AIDS in a tourist state of Goa India, using yearly epidemiological time series data. The authors used data from monitoring and evaluation unit, Goa state AIDS control society to demonstrate a novel use of the Lorenz curve, and Gini coefficient to determine the variability of HIV/AIDS in Goa in the three different types of samples (ICTC, ANC, Walk-in). We have also used ANOVA and a posteriori multiple comparison Tukey HSD tests to explores the geographical differences between all possible pairs of HIV positivity means that control alpha inflation. The overall combined Gini coefficient, an equality measure that ranges from 0 (perfect equality) to 1 (perfect inequality) was 0.40 indicating moderate concentration of HIV positive persons tested in Integrated Counselling and Testing Centre (ICTC). Females (Gini coefficient=0.39) were less concentrated of HIV positive persons than males (Gini coefficient=0.42). In Walk-In centers overall combined Gini coefficient was 0.49 indicating moderate but higher than ICTC concentration of HIV positive persons in overall combined population. Females (Gini coefficient=0.46) were less concentrated of HIV positive persons than males (Gini coefficient=0.59).Five homogeneous subgroups were formed on bases ofTukey HSD analysis, in which Salcete and Mormugao taluks both from South Goa district have the highest HIV positivity rates and Tiswadi and Bardez taluks both from North Goa district have the second highest HIV positivity rates. This is of critical importance as the authors continue to explore novel approaches to investigate the geographic variation in disease etiology.

INTRODUCTION

Globally, an estimated 35.3 (32.2–38.8) million people were living having infected with HIV in 2012. In Asia around 0.60% of the world's population wereliving with HIV followed by sub-Saharan Africa. India accounts for roughly half of Asia's HIV prevalence in 2009 [1]. Sexual transmission is driving the epidemic throughout India and accounts for nearly 90% of the infections [2]. Economic and Social Commission for Asia and the Pacific, 2008, reports that nearly 50 million people in the Asia and Pacific region are not living in their native countries. However, the number of international migrants in Asia is vastly outweighed by people who migrate internally. Even though migration itself is not a risk factor for HIV infection, the process of migration and the circumstances in which the mobility occurs can increase vulnerability to the infection [3]. Past studies have shown that migrant population act as bridge population while transferring the virus from high-risk groups such as sex workers to low risk groups such wives or other non commercial sexual partners (See, [4], [5] and [6]).

The Indian coastline is about 7517 km, about 5423 km along the mainland accounts for 2094 km including the Andaman and Nicobar, and Lakshadweep Islands (See, [7]). On this coast line lie India's four high HIV prevalent states: Maharashtra, Andhra Pradesh, Karnataka, and Tamil Nadu. In the Indian context, when it comes to the mobile population, it is mostly truckers and labour migrants who have been given more attention from the National AIDS Control Organization. The first AIDS case in India was detected in 1986 and since then HIV infection has been reported in all states and union territories (See, [8]). The spread of HIV in India has been uneven. Although much of India has a low rate of infection, certain places have been more affected than others. HIV epidemics are more severe in the southern half of the country and the far north-east. In 2011, among the States, Manipur has shown the highest estimated adult HIV prevalence of 1.22 %, followed by Andhra Pradesh (0.75 %), Mizoram (0.74 %), Nagaland (0.73 %) Karnataka (0.52 %), Goa (0.43 %) and Maharashtra (0.42 %). Goa is one of the coastline state of India with a population of 1.34 million ([9]). For the purposes of HIV/ AIDS surveillance, Goa is divided into two districts: the North Goa is one of India's high prevalence districts, with more than one percent of women testing positive at antenatal care while the south is having medium prevalence, with a high level of HIV/AIDS among high-risk groups (more than five percent prevalence among those attending STI clinics) (See, [10]). HIV infection is now prevalent in all parts of Goa and majority of the cases are reported in the four coastal Talukas viz. Salcete (18.4%), Mormugao (12.8%) in South Goa District and Tiswadi (11.5%)

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and Bardez (14.9%) in North Goa District during 1998 to 2013 [9]. Out of 505 cases reported in Goa during the year 2013, 23.2% belong to other States (foreigners/not specified). 79.8% of the cases detected in Goa during 2013 belonged to the age group 15-49 years which are economically productive. In this article we have tried to describe the trend and pattern of prevalence of HIV in the general population in Goa and different taluka's of two districts of Goa for the period 2002 to 2012 by using different statistical tools and further we have discussed the implications for HIV prevention programmes.

METHODS AND MATERIALS

This study was carried out by using secondary data of HIV for Goa and different Taluka's of Goa. The sample population included 2,11,239 patients tested in ICTC, 1,07,264 in ANC and 79,740 in Walk-in in Goa. The data for the study was collected from different reports of Goa State AIDS control Society over a period of 10 years from 2003 to 2013 ([9]). The data present in the electronic format was abstracted from the Microsoft Excel database and imported into R-programme, SPSS and GPIS statistical software's and analysed using different statistical methods. In particular we used Lorenz curves and the corresponding Gini coefficients to formally analyse the three different type of samples (ICTC, ANC, Walk-in) variability of HIV/AIDS in Goa. The Lorenz curve is a graphic representation of the distribution of some commodity, such as income, against the uniform distribution that represents equality, such as proportion.

The Gini coefficient is a summary measure for the Lorenz curve; it allows for comparison of concentration levels without graphic displays. If the Lorenz curves of multiple diseases do not cross, then an ordering of the concentration of the disease will be the same as an ordering of the Gini coefficients. In addition, Gini coefficients can be used to assess concentration levels across studies. The Gini coefficient measures twice the percentage of the total area above the diagonal, which is encompassed by the Lorenz curve, and rages from 0 to 1 (see, [11, 12, 13]). A Gini coefficient of 1 indicates concentration of all disease in a single sample tract, whereas a value of 0 indicates identical rates in all sample tracts. For HIV/AIDS, the three different type of samples present a special problem in applying Lorenz curves, which are usually applied to variables that can be broken down into fractions of whole. Detailed methodological information on the use of Lorenz curves and Gini index, including motivation interpretation and computation, is reported by Lee [11].

To plot the Lorenz curve, the observations are first either arrayed individually or grouped in class intervals according to the appropriate independent variate. Then the cumulative percentage of number of HIV positive persons (Y_i) is plotted against the cumulative percentage of number of persons tested for HIV positive (X_i). For comparison a diagonal line is drawn at 45^0 to show the condition of equal distribution. The Gini concentration ratio measures the proportion of the total area under the diagonal that lies in the area between the diagonal and the Lorenz curve. We estimate this area via the unbiased Gini coefficient [14, 15, 16], given by

$$G = \frac{1}{n-1}\left[\frac{\sum_{i=1}^{n}(2i-n-1)x_i}{\sum_{i=1}^{n}x_i}\right]$$

where x_i is the relative percentage of HIV positive persons within a given time, '*i*' is the rank of the time according to the relative percentage of HIV positive persons within a given time, and *n* is the total number of class intervals or time points.

RESULTS

Out of 398243 persons tested for HIV positive a total of 13083persons werefound to have HIV positive during the study period from 2003 to 2013. HIV positive testing procedure is carried out by the Government of Goa in three different circumstances; Integrated Counseling and Testing Centre (ICTC), *AnteNatal* Care (ANC) centers, Walk-In centers. In its report HIV AIDS in Goa in 2014 [9], it has presented data from 1986 to 2014, and more detailed information regarding sex, age, region group wise data are given from 2003 onwards. Hence we consider our study period from 2003 to 2013.During the study period in ICTC 211239 persons were tested for HIV positive out of which 1411 were found to HIV positive and out which 968 had died during the period. During the study period a number of HIV positive cases in males are more than that of females. Further, the number of HIV positive cases among males went on decreasing slowly, but in case of females it got increased initially and latter decreased. The same trend was observed in number of AIDS cases and number of death cases (See, Fig. 1).

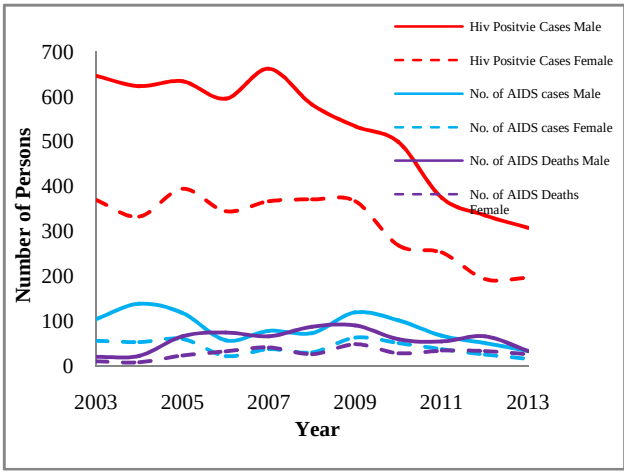

Fig. 1 Sex wise distribution of number of HIV positive cases, number of AIDS cases and number of deaths due to AIDS in Goa from 2003-2013.

Further, the data is analysed by the age groups of males and females for the period 2003 to 2013. Age distribution of HIV positive individuals from 2003 to 2007 were in age group less than or equal to 14, 15 – 29, 30 – 49, and above 50 and were as from 2009 to 2013 age groups are less than equal to 14, 15 – 24, 25 – 34, 35 – 49, and above 50.

The data presented in Figure 2 shows that in the age group 30 to 49 the number of HIV infected persons were more than other age groups and followed by age group 15-29 from 2001 to 2007 except from 2000 to 2003 were females whowere in age group 15- 29 accounted for highest HIV infected persons. Also the data is presented in Figure 3 for the period 2008 to 2013 reveals that the number of HIV infected persons were

more in age group 35-49, followed by age group 25 to 34. Overall analysis reveals that HIV epidemic is concentrated in the sexually active age group and it is more active in the younger age for females than that of males.

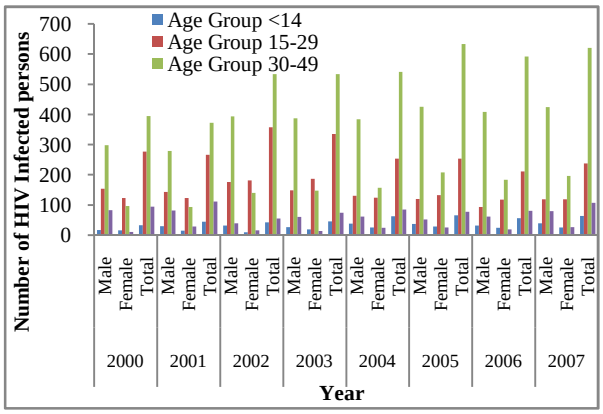

Fig. 2 Distribution of number of HIV infected persons by age group in Goa from 2003-2007.

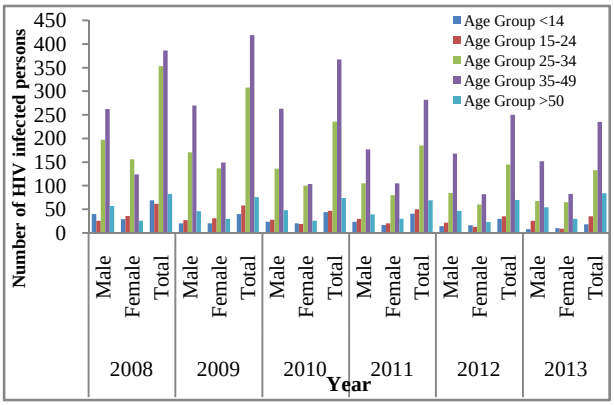

Fig. 3 Distribution of number of HIV infected persons by age group in Goa from 2008-2013.

Table 2 Number of Tested and Positive Cases in ANC

Year	Number of Tested Cases	Number of Positive Cases	% Positivity	CL
2003	2,567	38	1.48	(0.011-0.020)
2004	3,717	47	1.26	(0.010-0.017)
2005	3,068	41	1.34	(0.010-0.018)
2006	7,357	75	1.02	(0.008-0.013)
2007	10,432	65	0.62	(0.005-0.008)
2008	11,053	65	0.59	(0.005-0.008)
2009	12,253	58	0.47	(0.004-0.006)
2010	11,802	52	0.44	(0.003-0.006)
2011	14,609	35	0.24	(0.002-0.003)
2012	14,053	22	0.16	(0.001-0.002)
2013	16,353	27	0.17	(0.001-0.002)

The number of tested and positive cases of HIV in ICTC centre is shown in Table 1. The data was collected and analysed for a total of 2,11,219 patients from ICTC centre. Out of which 9255 patients were found to be HIV positive of which 968 had died during the period 2003 to 2013. Further, a yearwise analysis shows that the HIV seropositve rate for male got increased from 9.88 (CL 0.092-0.106) in 2003 to 10.60 (CL 0.098-0.114) in 2005 and later on went on decreasing upto 1.31 (CL 0.012-0.015) in 2013. In case of females the rate of HIV seropositive got decreased i.e., 7.19 (CL 0.065-0.079) in 2003 to 1.31 (CL 0.011-0.013) in 2013. But the total rate of seropositive was fluctuating around 8.5 for the first four years from 2003 to 2005 and later it went on decreasing from 8.24 (CL 0.078-0.087) in 2006 to 1.31 (CL 0.012-0.014) in 2013 (See,Table 1).

The number of tested and positive cases in ANC is shown in Table 2. A total of 1,07,264 female patients were tested out of which 525 patients were found to be HIV positive for the study period from 2003 to 2013. The seropositve rates for females has been on continuous decrease i.e.,from 1.48 (CL 0.011 – 0.020) in 2003 to 0.17 (CL 0,001 – 0,002) in 2013 (See,Table 2).

Table 1 Number of Tested and Positive Cases in ICTC

Year	Number of Tested Cases			Number of Positive Cases			% Positivity			CL		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
2003	6538	5144	11682	646	370	1,016	9.88	7.19	8.70	(0.092-0.106)	(0.065-0.079)	(0.082-0.092)
2004	5974	5245	11219	623	333	956	10.43	6.35	8.52	(0.097-0.112)	(0.057-0.070)	(0.080-0.091)
2005	5980	5834	11814	634	395	1,029	10.60	6.77	8.71	(0.098-0.114)	(0.062-0.074)	(0.082-0.092)
2006	5860	5163	11023	595	345	940	10.15	6.68	8.53	(0.094-0.111)	(0.060-0.074)	(0.80-0.091)
2007	7806	4679	12485	662	367	1,029	8.48	7.84	8.24	(0.079-0.091)	(0.071-0.086)	(0.078-0.087)
2008	11215	4467	15682	582	371	953	5.19	8.31	6.08	(0.048-0.056)	(0.075-0.092)	(0.057-0.065)
2009	14988	6229	21217	534	367	901	3.56	5.89	4.25	(0.033-0.039)	(0.053-0.065)	(0.040-0.045)
2010	15031	6586	21617	499	269	768	3.32	4.08	3.55	(0.030-0.036)	(0.036-0.046)	(0.033-0.038)
2011	16107	9418	25525	375	253	628	2.33	2.69	2.46	(0.021-0.026)	(0.024-0.030)	(0.023-0.027)
2012	19121	11372	30493	336	194	530	1.76	1.71	1.74	(0.016-0.020)	(0.015-0.020)	(0.016-0.019)
2013	23467	15015	38482	308	197	505	1.31	1.31	1.31	(0.012-0.015)	(0.011-0.015)	(0.012-0.014)

Table 3 Number of Tested and Positive in Walking

Year	Number of Tested Cases			Number of Positive Cases			% Positivity			CL		
	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total
2003	570	2378	2948	107	78	185	18.77	3.28	6.28	(0.158-0.222)	(0.026-0.041)	(0.055-0.072)
2004	677	2912	3589	92	87	179	13.59	2.99	4.99	(0.112-0.164)	(0.024-0.037)	(0.043-0.058)
2005	934	3378	4312	192	180	372	20.56	5.33	8.63	(0.181-0.232)	(0.046-0.061)	(0.078-0.095)
2006	1078	1218	2296	191	141	332	17.72	11.58	14.46	(0.156-0.201)	(0.099-0.135)	(0.130-0.160)
2007	1536	964	2500	228	163	391	14.84	16.91	15.64	(0.132-0.167)	(0.147-0.194)	(0.142-0.171)
2008	2231	1032	3263	186	179	365	8.34	17.34	11.19	(0.073-0.096)	(0.152-0.198)	(0.102-0.123)
2009	4616	1746	6362	209	192	401	4.53	11.00	6.30	(0.040-0.052)	(0.096-0.126)	(0.057-0.069)
2010	4321	2125	6446	181	146	327	4.19	6.87	5.07	(0.036-0.048)	(0.059-0.080)	(0.046-0.056)
2011	7581	4330	11911	162	120	282	2.14	2.77	2.37	(0.018-0.025)	(0.023-0.033)	(0.021-0.027)
2012	10630	6119	16749	131	96	227	1.23	1.57	1.36	(0.010-0.015)	(0.013-0.019)	(0.012-0.015)
2013	12060	7304	19364	156	86	242	1.29	1.18	1.25	(0.011-0.015)	(0.010-0.014)	(0.011-.014)

Also the number of tested and positive cases in Walk-in is shown in Table 3. A total 79,740 number of patients were tested during the study period 2003 to 2013, out of which 46,234 were male patients and 33,506 were female patients. The result of the analysis is reveals that the rate seropositve for males was more than that of females from 2003 to 2006 and exact reverse was observed from 2007 to 2013.

In case of males the rate of seropositve got increased from 18.77 (CL 0.158 – 0.220) in 2003 to 20.56 (CL 0.181 – 0.232) in 2005 and later it went on decreasing slowly from 17.72 (CL 0.156 – 0.201) in 2006 to 1.29 (0.011 – 0.015) in 2013. But in case of females the seropositve rate shown drastic increase from 3.28 (CL 0.026 – 0.041) in 2003 to 17.34 (CL 0.152 – 0.188) in 2008 and later from the year 2009 the rate of seropositve got decreased from 11.00 (CL 0.096 – 0.126) to 1.18 (CL 0.010 – 0.014) in 2013 and the same trend was observed in case of total number of cases.

Table 4 Results of *t*-test for testing the equality of mean % of HIV positive cases with p-values

Sl No	Variables	t value	p value
1	ICTC Male and ICTC Female	0.541	0.594
2	ICTC Male and Walk-in Male	-1.437	0.166
3	ICTC Female and ANC Female	6.079**	0.000
4	ICTC Female and Walk-in Female	-1.027	0.317
5	ICTC Total and Walk-in Total	0.8	0.433
6	Walk-in Male and Walk-in Female	0.83	0.417

Further the analysis of *t*-test for testing the equality of mean percentages of HIV positive cases in these different categories are shown in Table 4. The results shows that generally there is no significance in the mean percentages of HIV positive cases in these different categories (p-values are greater than 0.05 the level of significance) except in the comparison of ICTC females with ANC females categories.

This is mainly because in ANC all most all pregnant females will be tested for HIV positive where as in ICTC a group of people who experience HIV symptoms will be tested for HIV positive. The analysis also reveals that there is no much difference in the males and females in any of the categories.

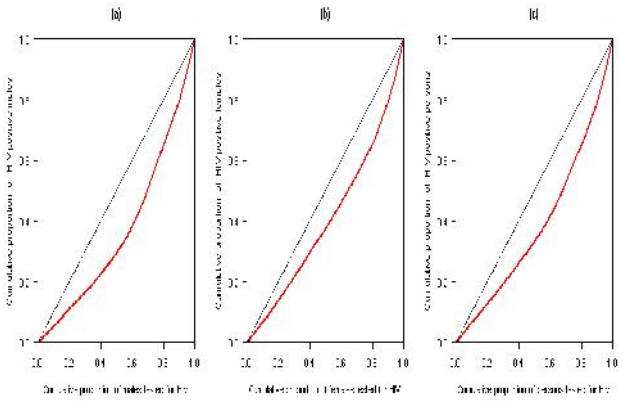

Fig. 4

Fig. 4: The Lorenz curves illustrate the distribution of the total number of HIV positive persons as function of total number of persons tested for HIV for the (a) male population (b) female population and (c) combined male and female population at Integrated Counselling and Testing Centre (ICTC).

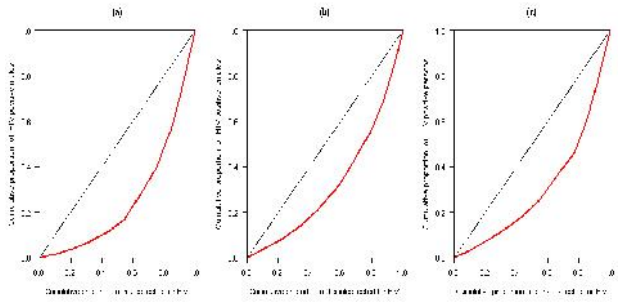

Fig. 5

Fig. 5: The Lorenz curves illustrate the distribution of the total number of HIV positive persons as function of total number of persons tested for HIV for the (a) male population (b) female population and (c) combined male and female population at Walk-In centers.

Fig. 4, a – c, displays Lorenz curve by sex and combined population of number of HIV positive persons as function of total number of persons tested for HIV at Integrated Counselling and Testing Centre (ICTC). The Gini coefficient ranges between 0 and 1. A value close to 0 indicates a smaller number of concentrations of HIV positive persons compared with that of at-risk population in the given time, and a value close 1 indicates more number of concentrations of HIV positive persons compared with that of at-risk population in the given time. The overall combined Gini coefficient was 0.40 indicating moderate concentration of HIV positive persons in overall combined population. Females (Gini coefficient=0.39) were less concentrated of HIV positive persons than males (Gini coefficient=0.42). The Lorenz curve for males (Fig. 4a) bends further way from the axis of equality than the curve for females (Fig. 4b), suggesting that concentration of HIV is more in males than that of females. Similarly Fig. 5, a – c, displays Lorenz curve by sex and combined population of number of HIV positive persons as function of total number of persons tested for HIV at Walk-In centers. The overall combined Gini coefficient in Walk-In centers was 0.49 indicating moderate but higher than ICTC concentration of HIV positive persons in overall combined population. Females (Gini coefficient=0.46) were less concentrated of HIV positive persons than males (Gini coefficient=0.59).

Talukawise Distribution of HIV positive cases

For administrative Goa state is divided in two districts, each having six Taluks. Talukawise percentage of HIV positivity is shown in Fig. 4 and it demonstrates that four coastal Talukas viz. Salcete, Mormugao in South Goa District and Tiswadi and Bardez in North Goa District during 2003 to 2013 are having more percentage of HIV positive cases than the others for the period 1998-2013.

In Tiswadi and Mormugao the rate of HIV positive got decreased from 1998-2013 but in case of Bardez the rate of positivity shows a reverse trend. The rate of positivity in Salcete was fluctuating around 18 in most of the years. Further it was observed that in the remaining Taluka's the rate of positivity has been fluctuating between ranges 2 to 5.

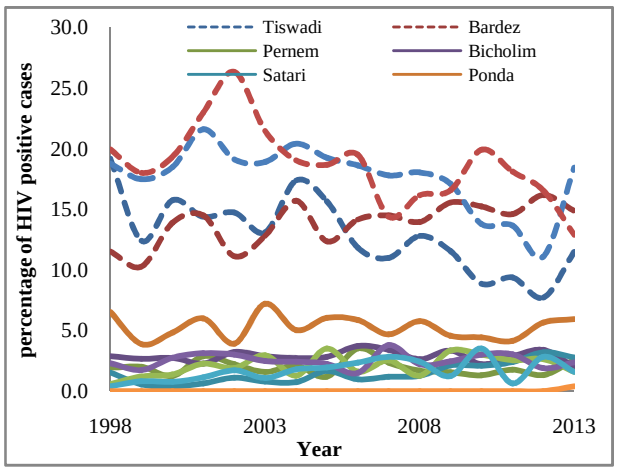

Fig. 6 Talukawise distribution of percentage of HIV positive cases of Goa from 1998-2013.

Further, the test of significance, analysis of variance (ANOVA) was used to compare the differences in mean of percentage of HIV positive cases in different Taluk's. Geographical heterogeneity in HIV transmissibility was statistically significant in the Goa (one-way ANOVA for comparison of means of percentage of HIV positive cases in different Taluk's, F=267.602, p<0.0001). Also Geographical heterogeneity in HIV transmissibility was statistically significant within two districts of Goa (one-way ANOVA for North Goa, F=198.713, p<0.0001; and for South Goa,F=366.625, p<0.0001). Rejection of the null hypothesis in ANOVA tells us only that not all population means are equal.

It does not indicate which attachmentgroups are significantly different from others. One way to further examine group differences is to use post-hoc or a posteriori multiple comparison tests, such as the Student-Newman-Keuls or Tukey HSD test. In our example, we haveused Tukey HSD tests to test for differences between all possible pairs of means that control alpha inflation. The Table 5, shows the homogeneous subsets generated in SPSS using Tukey HSD tests, which formed five homogeneous subgroups. First subgroup which has very low HIV positivity rate is Dharbandora, Satari (east side of Goa towards Karnatka, not has costal area), and Pernem north taluka of Goa towards Maharashtra and Canacona South end taluka of Goa. Second homogeneous group which is slightly high HIV positivity rate consists of Sanguem, Quepem and Bicholim taluka's.

Third group which has moderate HIV positivity rate consist only one taluka i.e., Ponda, which is close to highest HIV positive taluks and Goa state capital Panaji and which also has acoastal area. Forth homogeneous subgroup which is second highest HIV positivity rate consists of Tiswadi and Bardez both from North Goa district and these taluka's are along the costal line. Fifth homogeneous group which has highest HIV positivity rate consists of Salcete and Mormugao both from South Goa district and these taluka's are along the costal line. This analysis clearly reveals that HIV/AIDS epidemic in tourist state Goa is highly concentrated along the costal line. The HIV/AIDS epidemic situation in Goa state is depicted in below Goa map (See, Fig. 7).

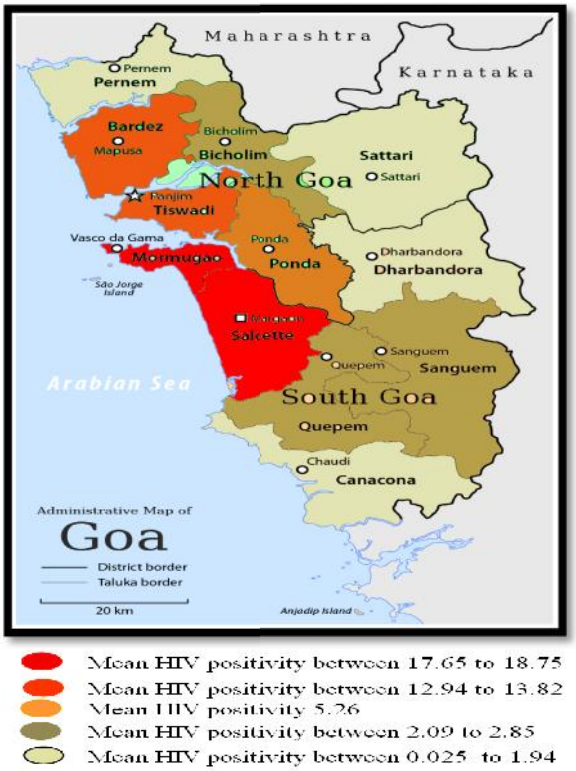

Fig. 7 Map showing the HIV/AIDS epidemic situation in Goa.

Table 5 The homogeneous subsets generated in SPSS using Tukey HSD tests along with p-values.

Factors	Subset for alpha = 0.05				
	1	2	3	4	5
Dharbandora	.0250				
Satari	1.4625				
Canacona	1.6688				
Pernem	1.9438				
Sanguem		2.0938			
Quepem		2.5062			
Bicholim		2.8500			
Ponda			5.2688		
Tiswadi				12.9375	
Bardez				13.8125	
Salcete					17.6563
Mormugao					18.7250
Sig.	.069	.471	1.000	.950	.826

DISCUSSION

This study has explored the geographical and demographic patterns of transmissibility of HIV/AIDS in a tourist state Goa of India, using yearly epidemiological time series, made available by monitoring and evaluation unit, Goa state AIDS control society in its report HIV/AIDS in Goa [9]. We identified spatial variations of the transmissibility of HIV by age and sex using various statistical methods. Overall analysis reveals that HIV epidemic is concentrated in the sexually active age group and it more active in the younger age for females than that of males. We found similar transmissibility variations across the geographical area, even though HIV positivity shows adecreasing trend from 1998 to 2014 our result indicates that in four taluks viz, Mormugao, Salcete, Bardez and Tiswadi HIV positivity is having high fluctuations and are the most affected taluks. These four taluks are in the costal belt of Goa state and

are tourist centers of attraction; hence attention should be given to control the epidemic in these areas. To our knowledge no epidemiological study has examined the concentration of HIV positive persons to the total persons tested for HIV by using the measure of inequality, Such as the Lorenz curve and the Gini coefficient in the Indian contest. Proportion of females infected to total HIV positive cases in Goa from 1988 to 2014 shows increasing trend (16.7 % in 1988 to 45.0% in 2014, See, [9]). The recent halt in the declining incidence rates of HIV in women's indicates that new control strategies are required and hence it is time to educate women's about the HIV/AIDS epidemic and its impacts. The incidence of HIV positivity rates reported in Goa are substantially higher than in most other Indian provinces.

Limitations of this study include the study of differences in incidence rates of urban and rural areas as the study is based on the secondary data. There are still many unanswered questions that will require research. Chief among them these is operational research that is directed towards a better understanding of how to design and implement effective control programmes for higher risk communities. Network analysis could also be used to provide a better understanding of the specifics of transmission patterns and to control outbreaks more efficiently.

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