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Urban and Rural HIV Estimates among Adult Population (15 - 49 Years) in Selected States of India Using Spectrum Data

Lincoln Priyadarshi Choudhury[1], Jayaraman Prabakaran[2]

[1]Guwahati, India
[2]Tamil Nadu State AIDS Control Society (TANSACS), Chennai, India
Email: lincolnchoudhury@gmail.com, prabakarandrnaco@gmail.com

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Abstract

HIV estimation has become a standard tool for understanding the epidemic. Although the majority of India's population lives in rural areas, to date, an exploration of the urban and rural HIV epidemic has not been undertaken. The objective of this study is to develop HIV estimation based on urban and rural adult populations in selected states of India to understand the difference in HIV related indices geographically. Ten states were selected based on HIV prevalence levels-Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Manipur, and Nagaland, Mizoram, Punjab, Odisha and Jharkhand. Spectrum, version 4.53 beta 19, was used. Data files of Indian national estimation, 2010-11 which included population, HIV Sentinel Surveillance, Integrated Bio Behavioral Assessment and program coverage data, were used and alterations made wherever necessary. The urban and rural sub epidemic structures and their subpopulations were separately configured in the Estimation projection package and curve fitting done. Outputs for each state were separately analyzed. Findings show that HIV prevalence is lower in urban than rural areas in Tamil Nadu and Maharashtra; in Karnataka there is no difference in HIV prevalence in the urban and rural populations; and in the remaining seven states urban HIV prevalence is higher as compared to rural HIV prevalence. In the states of Andhra Pradesh, Tamil Nadu, Maharashtra, Odisha and Punjab, the number of people living with HIV, new HIV infections and deaths among people living with HIV is higher in the rural than in the urban population. An early and lower peak in HIV prevalence and incidence in the urban population was seen in Andhra Pradesh, Tamil Nadu, Karnataka and Nagaland, while in Maharashtra the rural peak was earlier and higher. Mizoram shows an earlier and lower peak in the rural population while Manipur shows an earlier and higher urban peak. In Odisha, the epidemic peaked earlier and was lower in the rural than the urban population. HIV prevalence in the urban population in Punjab was still peaking while HIV incidence was earlier and lower in the rural population. In Jharkhand, both urban and rural HIV prevalence and incidence are still increasing. Our findings indicate lower levels of HIV prevalence and incidence in the

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urban population as compared to the rural populations in Maharashtra and Tamil Nadu. In the remaining eight states, urban prevalence and incidence are higher than their rural counterparts. Future estimations of the HIV epidemic in the country need to adopt a similar approach to inform the design of appropriate state-level strategies for HIV prevention in urban and rural areas.

Keywords

HIV Sentinel Surveillance, HIV Estimation, HIV Prevalence, HIV Incidence, High Risk Group, Biological Behavioral Assessment

1. Introduction

Global estimates indicate a declining number of new HIV infections in most parts of the world, including India [1]. While there is a recent publication by Joint United Nations Programme on HIV/AIDS (UNAIDS) on the HIV epidemic in selected cities, [2] global information on the rural HIV epidemic is limited. HIV estimations for urban and rural areas have been separately undertaken in some high HIV prevalence countries like Ethiopia and Rwanda at the national level [3]. In 2003, while Rwanda reported high (13.2%) but declining urban HIV prevalence, rural prevalence was comparatively lower (2.8%) showing a stable to increasing trend [3]. Estimates from Ethiopia suggest that though HIV prevalence was higher in urban than rural areas, both areas showed a declining trend [4]. In Kenya, the urban and rural difference in HIV prevalence is becoming minimal [5].

India ranks third with respect to the number of people living with HIV/AIDS in the world [1]. The epidemic is concentrated among high-risk groups (HRGs), and over the last decade there has been a declining trend in the number of new infections [6]. The Indian government has made concerted efforts to reverse the HIV epidemic [7]. With more than 65% of India's population residing in rural areas [8], there have been reports of the HIV epidemic moving towards rural areas [9]. A community-based study in 2000 from Chennai, Tamil Nadu suggests that HIV prevalence is higher in urban than rural areas [10]. However, the National Family Health Survey, 2005-06 (NFHS-3) in Maharashtra state, and a population-based study from the state of Andhra Pradesh (2008), report that HIV prevalence is higher in rural than urban areas [11] [12]. While findings are mixed, it is imperative to understand the HIV scenario in urban and rural areas to improve the delivery of HIV prevention programs [13]. The national HIV estimation in India has used Spectrum software for rural-urban estimation, which combines the Spectrum and estimation package, and is globally recommended by UNAIDS [6] [14].

Though evidence suggests differences in HIV patterns in urban and rural populations in India, studies are limited to small geographic areas and the findings may not be generalizable. Further, national level urban-rural estimations have not been undertaken to date in India [6]. The objective of the study is to develop HIV estimation based on urban and rural adult populations in selected states of India to understand the difference in HIV related indices geographically.

2. Methodology

2.1. Material and Procedures

Based on reported HIV levels and trends of new infections, ten states of India have been selected for this study. Six states (Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra, Manipur and Nagaland) are high HIV prevalence states with declining new infections. Mizoram is a medium HIV prevalence state with stable new infections, while Punjab, Odisha and Jharkhand are low prevalence states that are showing increasing new infections in latest estimations [6]. Study period taken for analysis is 1981-2017. And this analysis was done from January 2013-Dec 2014.

2.2. Data and Tools

Data for the study were obtained from National AIDS Control Organization (NACO). The data used were Spectrum files and HIV Sentinel Surveillance (HSS) data for each state. Spectrum, version 4.53 beta 19, was used for estimations. This version includes the Estimation Projection Package (EPP) and AIDS Impact Module (AIM)

inbuilt in Spectrum [15]. The detailed statistical methods of Spectrum is given elsewhere [6] [14]-[16] and appropriate input were given as needed to run the estimation. The Demproj module was used for demographic projections, based on population data, migration, mortality and fertility data [6]. The Spectrum files included information on the general population, HRGs and program statistics, including adult and child anti-retroviral therapy (ART) coverage, mother-to-child transmission of HIV (MTCT), treatment eligibility, and ratio of female-to-male HIV incidence (15 - 49 years). The age group for this analysis was taken as 15 - 49 years for all parameters, and the data are presented separately for each state. In addition, proportions were calculated and z tests conducted to test statistical significance.

2.3. Epidemic Structure

The concentrated epidemic type was selected in EPP. During HSS rounds, information on each participant's residence status (urban or rural) was collected. Urban and rural sub epidemic structures were separately configured for each state (**Figure 1**). The urban sub epidemic structure consisted of HRGs—injecting drug users, men who have sex with men, and female sex workers)—and low-risk groups (the remaining population) based on the data used in national estimation for each state [12]. All rural populations were considered to be low risk.

The population distribution for each sub-population group was calculated decadal-wise for the period 1981-2017 using published data [8] [17]. Assumptions on the duration of sexual behavior and the composition of the population were based on the last national estimations [6].

2.4. Surveillance Data

HSS data for HRGs and Integrated Bio-Behavioral Assessment data for HRGs, where available, were used [18] for projecting HRG curves. HSS data for antenatal care (ANC) was used for projecting the remaining population curves for urban areas and all population curves for rural areas. Though urban-rural analysis based on the location of HSS sites has been reported elsewhere [19] [20], these sites often do not fully represent the characteristics of these areas [21]-[23]. For this analysis we used the actual residence of clients recorded in the HSS ANC rounds, rather than sites designated as urban or rural sites, for projections of the HIV epidemic in India. HSS ANC sites, which included urban and rural data, with a minimum of 300 samples, were considered for analysis during national estimations. For this analysis any urban or rural locality HSS ANC data with a sample size of less than 100 was not included in the analysis.

2.5. Curve Fitting and Fitting Results

For each sub-population projection, the EPP classic model was used with 1900 iterations and 3000 resamples. Advance options were applied as appropriate. The best fitting curves of each HRG sub-population and the urban

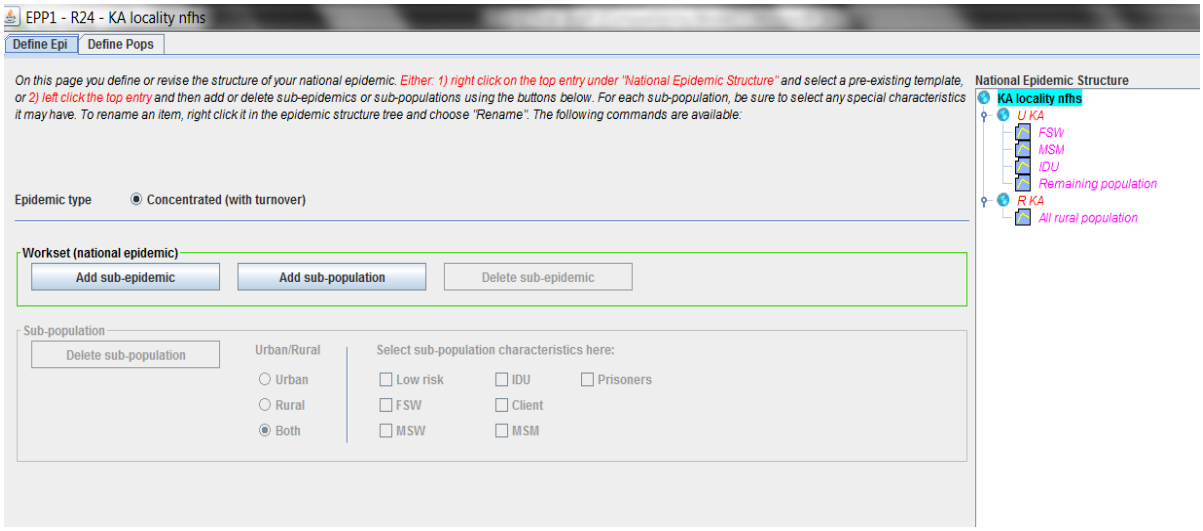


Figure 1. Epidemic structure in estimation and projection package in spectrum.

general population were combined to produce the urban epidemic curve. The best fitting curve of the rural population was directly obtained.

2.6. Calibration Factors

Calibration for ANC sites was required to address the difference between ANC prevalence in population-based surveys and ANC positivity in HSS sites [24]. As this analysis required separate calibration factors for urban and rural ANC, two methods were used for calibration: 1) NFHS data for each state, where available, were considered; 2) for all other states, the calibration factor used in the latest round of HIV estimation was juxtaposed with the HSS ANC data for sites for three years (2005, 2006, and 2007).

2.7. Ethical Approval

The data sharing committee and Institutional Review Board of NACO, Ministry of Health and Family Welfare, Government of India approved the use of Spectrum and HSS data.

2.8. Validation

The parameters of curve fitting-1) start time of the epidemic; 2) force of infection; and 3) peak level of the epidemic curve-were kept on par with the national estimation values. The total number of adult rural and urban sub-populations was matched with the total population for each state. The infections and number of annual deaths were within the upper and lower bounds of the earlier published estimation data [6].

3. Results

3.1. Current HIV Levels

Table 1 presents urban-rural HIV prevalence among adults (15 - 49 years). Data indicate more than 1% HIV positivity in population level HIV prevalence in Manipur state, urban Manipur, urban Nagaland and urban Mizoram. In urban Tamil Nadu and urban Maharashtra, HIV prevalence is lower than in the rural population, while in Karnataka HIV prevalence is similar for both urban and rural populations. In the remaining seven states, HIV prevalence is higher in the urban than the rural population. Apart from Karnataka, in all other states urban-rural differences in HIV prevalence were statistically significant ($p \leq 0.05$).

Table 2 presents data on people living with HIV (PLHIV), new HIV infections and deaths among adult

Table 1. Adult (15 - 49 years) HIV prevalence among high-risk groups and the remaining population, selected states of India, 2011.

State	Urban				Rural		State prevalence %	p value, 99% significance
	IDU	MSM	FSW	Remaining population	All population	All population		
Andhra Pradesh [AP]	5.63	15.51	8.18	0.73	0.83	0.76	0.78	<0.001
Tamil Nadu [TN]	7.90	2.68	2.79	0.16	0.17	0.32	0.25	<0.001
Karnataka [KA]	1.27	8.21	5.88	0.46	0.51	0.50	0.51	1.00[#]
Maharashtra [MH]	18.99	9.48	5.98	0.42	0.45	0.51	0.49	<0.001
Manipur [MN]	20.80	14.40	6.37	1.58	2.72	0.75	1.32	<0.001
Nagaland [NG]	1.91	NA[*]	14.98	0.95	1.23	0.36	0.6	<0.001
Mizoram [MZ]	6.86	NA	4.31	0.82	1.16	0.31	0.75	<0.001
Odisha [OD]	7.72	4.98	2.34	0.35	0.36	0.27	0.29	<0.001
Punjab [PJ]	28.49	2.67	1.44	0.16	0.22	0.16	0.18	<0.001
Jharkhand [JH]	1.87	NA	1.03	0.37	0.37	0.11	0.18	<0.001

[*]NA: Not available, [#]-Not significant. IDU: Injecting Drug User, MSM: Men who have Sex with Men, FSW: Female Sex worker.

Table 2. Number of people living with HIV, new HIV infections and deaths among people living with HIV (15 - 49 years) in selected states of India 2011: urban and rural differences.

States	Number of PLHIV			Number of New HIV Infections			Number of Deaths among PLHIV		
	Urban	Rural	State Total	Urban	Rural	State Total	Urban	Rural	State Total
Andhra Pradesh	128,242	247,509	375,751	7273	14,036	21,309	8641	16,679	25,320
Tamil Nadu	33,830	67,650	101,470	680	1370	2060	1830	3670	5500
Karnataka	67,074	108,452	175,526	3091	4998	8089	4395	7106	11,501
Maharashtra	132,336	180,124	312,461	6004	8335	14,340	7736	10,738	18,474
Manipur	12,409	8671	21,080	662	462	1123	807	563	1370
Nagaland	3824	3155	6980	153	126	279	294	242	536
Mizoram	3824	969	4793	335	85	419	170	43	213
Odisha	13,974	53,343	67,317	1086	4146	5233	976	3727	4703
Punjab	12,688	16,072	28,759	1419	1797	3216	393	497	890
Jharkhand	15,801	15,441	31,242	3025	2956	5982	530	518	1048

PLHIV: People Living with HIV.

PLHIV (15 - 49 years) by urban-rural location in 2011. In the states of Andhra Pradesh, Tamil Nadu, Maharashtra, Odisha and Punjab, the number of PLHIVs, new infections and deaths was higher in rural than in urban populations.

3.2. Trends in HIV Prevalence and Incidence: 2007-2011

Table 3 presents a comparison of urban and rural HIV incidence in select states. Data indicate higher HIV incidence in rural Andhra Pradesh (more than 43 per 100,000 population new infections), followed by Manipur and Maharashtra (with 40 and 24 per 100,000 population new infections respectively). Among the urban population, HIV incidence was highest in Manipur (145 new infections per 100,000 population) followed by Mizoram and Jharkhand (102 and 71 per 100,000 population new infections respectively). Overall, Manipur, Mizoram and Andhra Pradesh had the highest number of new infections (73, 68 and 45 per 100,000 population new infections respectively) in 2011.

Figure 2 presents estimated trends in urban and rural HIV prevalence and incidence in the ten states from 1985-2015. As shown in the Figure, while the HIV epidemic started in the mid-1980s in the states of Andhra Pradesh, Tamil Nadu, Maharashtra, Karnataka, Manipur Nagaland and Punjab, in Mizoram, Odisha and Jharkhand, the epidemic started in the early 1990s mainly in the urban areas. The epidemic peaked at different times: Andhra Pradesh, Tamil Nadu, Karnataka and Nagaland show an early and lower peak for both prevalence and incidence in the urban compared to the rural population, while in Maharashtra, the rural peak was earlier and higher than the urban peak for both prevalence and incidence. Mizoram shows an earlier and lower peak in the rural than the urban population, while Manipur shows an earlier and higher urban peak as compared to the rural peak. In Odisha, both incidence and prevalence peaked earlier and were lower in the rural as compared to the urban population. HIV prevalence in urban Punjab is still peaking, while incidence was earlier and lower in rural Punjab. In Jharkhand both urban and rural HIV prevalence and incidence are still showing an increasing trend.

4. Discussion

This study explores for the first time differences in the urban and rural HIV epidemic in India. Two key findings emerge from the study. One, urban HIV prevalence and incidence are higher than rural HIV prevalence in all states other than Tamil Nadu and Maharashtra, although the number of PLHIV and the number of new infections remain higher in rural than urban areas in all states except Manipur, Mizoram, Nagaland and Jharkhand. Two, in all the states, except Jharkhand, the incidence of HIV is declining.

Our analysis suggests that in most states, the overall epidemic started showing an increasing trend around

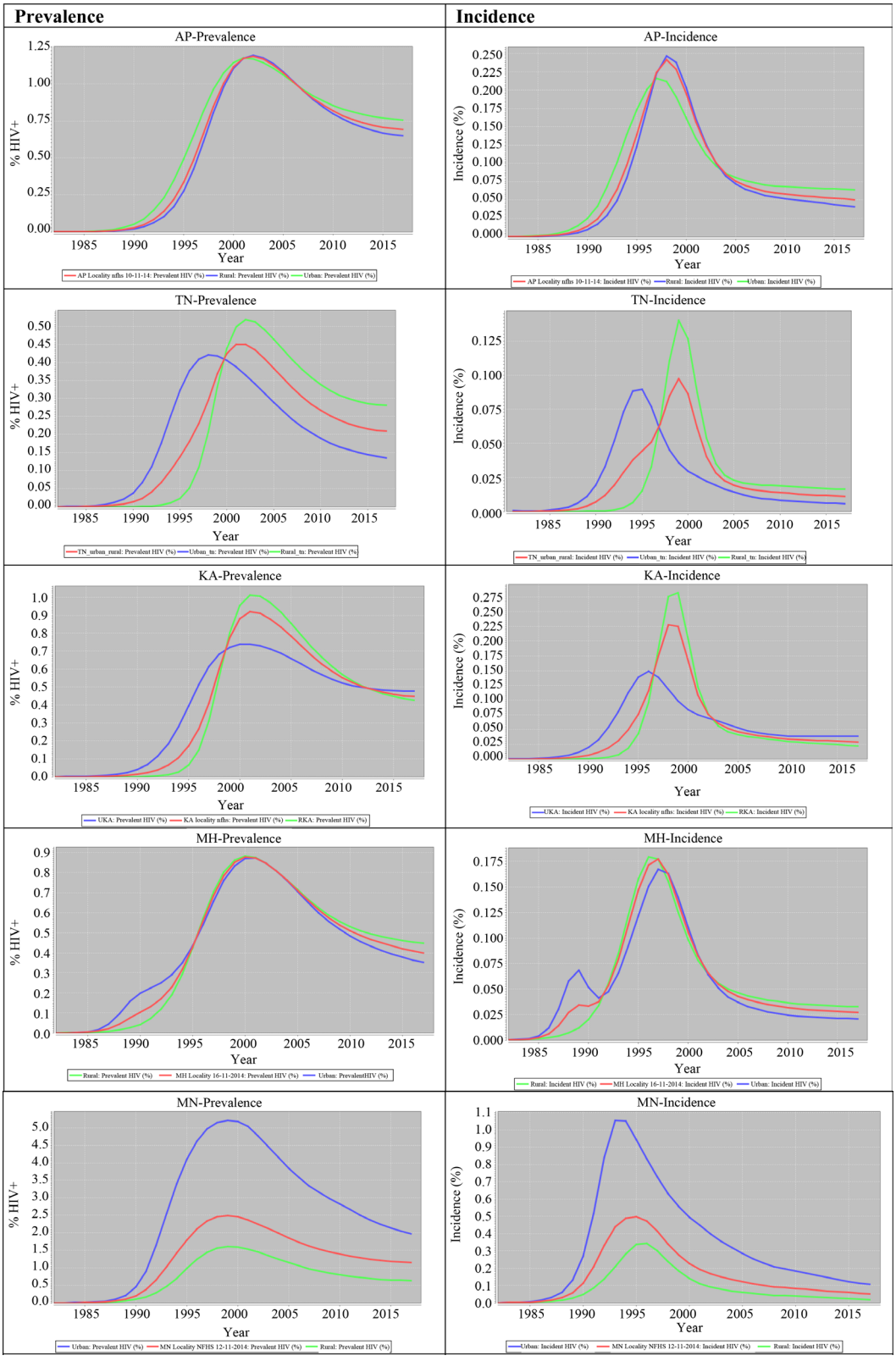
Table 3. Urban and rural HIV incidence by State, among adults (15 - 49 years) in selected states[#].

State/years	HIV incidence (%)			p value, 99% significance
	2007	2009	2011	
Andhra Pradesh	**53.98**	**47.82**	**45.4**	
Urban	52.6	48.08	47.11	
Rural	53.02	46.29	43.27	<0.001
Tamil Nadu	**6.88**	**5.63**	**5.2**	
Urban	4.96	3.97	3.57	
Rural	8.41	6.97	6.53	<0.001
Karnataka	**33.02**	**26.93**	**24.10**	
Urban	28.66	24.97	23.61	
Rural	34.54	27.18	23.55	<0.001
Maharashtra	**30.05**	**25.49**	**23.44**	
Urban	28.59	23.81	21.41	
Rural	29.95	25.77	24.09	<0.001
Manipur	**88.98**	**81.94**	**73.46**	
Urban	170.03	159.63	145.23	
Rural	51.23	46.16	40.72	<0.001
Nagaland	**35.3**	**29.29**	**24.99**	
Urban	55.06	52.42	49.51	
Rural	26.21	19.38	14.81	<0.001
Mizoram	**77.61**	**72.53**	**68**	
Urban	110.05	106.60	102.28	
Rural	37.34	31.28	27.2	<0.001
Odisha	**32.49**	**26.02**	**22.91**	
Urban	31.88	28.63	28.48	
Rural	31.81	24.87	21.25	<0.001
Punjab	**20.74**	**20.08**	**21.02**	
Urban	20.99	21.81	24.67	
Rural	19.97	18.45	18.22	<0.001
Jharkhand	**21.23**	**26.98**	**34.76**	
Urban	43.93	55.80	71.76	
Rural	13.3	16.92	21.81	<0.001

[#]Per 100,000 population.

1990; however, in Jharkhand and Orissa the epidemic started later (1995-2000). Overall, the epidemic is influenced by multiple factors. The different typologies of the virus that exist in India may have influenced the epidemic pattern [25]-[27], as HIV sub-typology has been associated with higher mucosal viral shedding, a surrogate marker of infectivity [28]. In addition, the epidemic curves may be influenced by the heterosexual transmission of HIV, particularly by female sex workers [29] in the majority of the states other than in north-east India, notably Manipur, where the epidemic is driven by injection drug use [30] [31]. Other population groups, like migrants, which were included in Odisha and Jharkhand, may have contributed to the HIV epidemic in these

states [9] [32] [33]. In most states other than Mizoram, during the initial period, the growth of the epidemic has been relatively higher in urban than in rural areas.



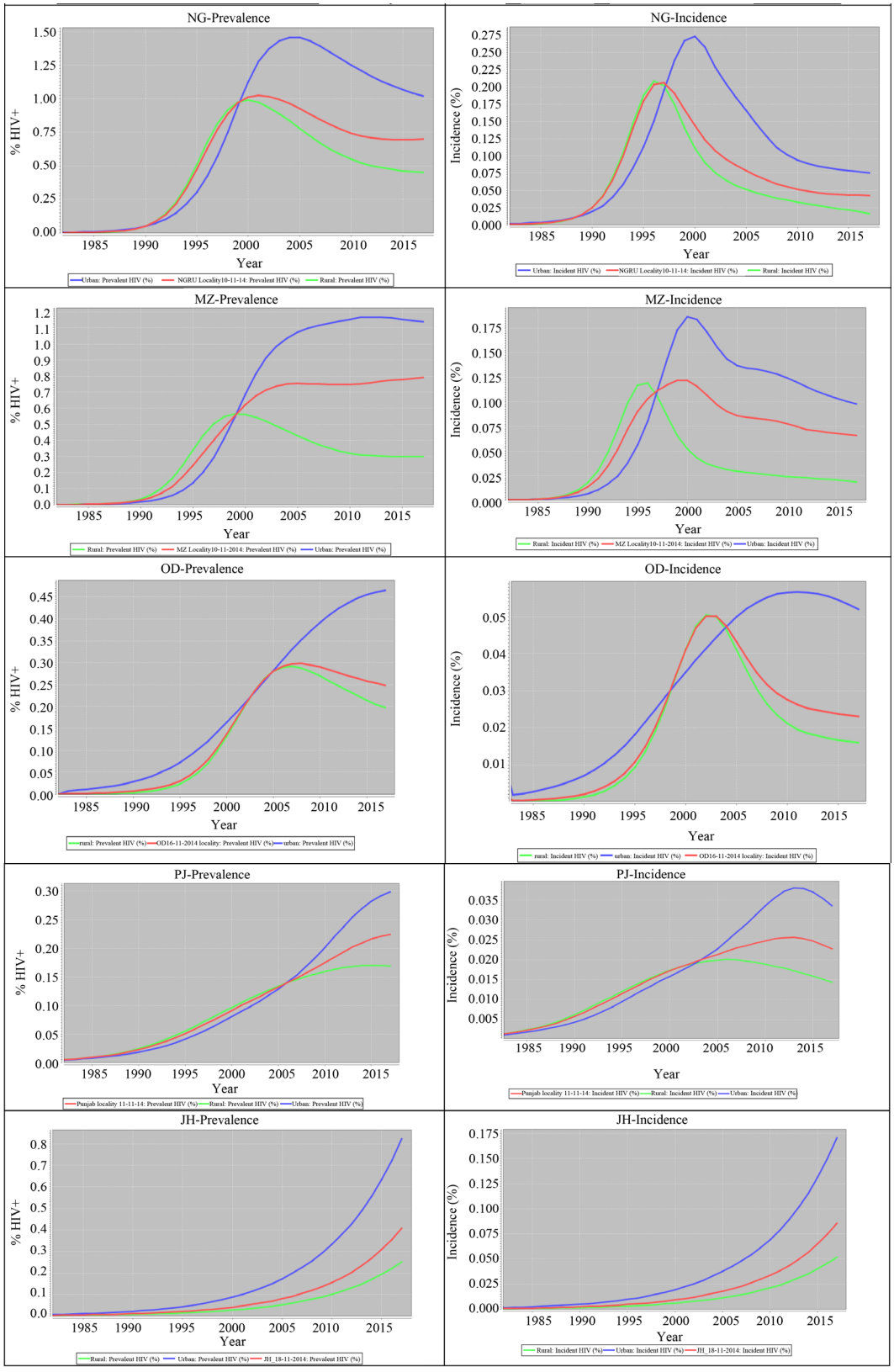


Figure 2. Comparison of urban and rural prevalence and incidence trends of HIV in selected states of India, 2011.

In addition to the factors discussed above, the varying degrees of achievement of prevention and treatment interventions may have influenced HIV prevalence in the intervention era. Prevention programs like targeted interventions, with interpersonal communication and behavior change components, have been shown to either reduce or move the HIV prevalence curves downwards [34]-[36]. However, most of these programs were initially limited to urban areas and later expanded to selected districts in rural areas through the Link worker Scheme [37]. ART increases life expectancy, reduces mortality and reduces the HIV transmission rate [38] [39]. India's ART program started in 2004 with an initial focus on medical colleges and district hospitals in six high prevalence states, [40] [41] which were mostly in urban areas. These have been scaled up from 2008 not only in urban areas but also in rural areas in the form of Link ART centers [40]-[43]. However, the delay in covering the rural population with the same intensity as the urban population with these key interventions need to be taken in to consideration when discussing the higher number of PLHIV and number of new infections and deaths in rural areas in most states.

As the country is moving from prevalence-based epidemic tracking to number-based epidemic tracking [44], with one of the key indicators being reducing the number of annual new infections, the relatively high number of PLHIV and new infections in most states would need to be addressed. The size of the PLHIV population and the number of new infections provide an indication of the possible transmission networks that exist in the respective states. It is important to emphasize that HRGs' network size does influence epidemic patterns [45]-[48] and could at times explain the transmission of HIV to rural areas and to other low risk populations [47]-[50]. In addition, the issue of high HIV incidence, even in states that are showing a declining epidemic, needs to be considered as the dynamics and risk factors in rural areas are not only affected by migration [32] [51] but also by the interplay of local factors and networks such as sex work [46] [52]-[54]. These factors may have also contributed to HIV prevalence and new infections in the states of Karnataka and Tamil Nadu in particular, and to the overall epidemic in the rural areas of selected states [55].

The findings of this study need to be interpreted in light of certain limitations. The current estimation may have been influenced by the changing methodology in HSS for recruiting samples. Though migrants [32] and transgenders/Hijras are recognized as separate high-risk population group [56] adequate data were not available to add them in the current estimation. Information on size estimation of the HRG population in rural areas was not available; thus separate epidemic structures for rural HRGs and for the rural general population could not be created.

5. Conclusion

In short, our findings indicate lower levels of HIV prevalence and incidence in the urban population as compared to the rural population in Maharashtra and Tamil Nadu. In the remaining eight states, urban HIV prevalence and incidence are higher than rural prevalence and incidence. Future estimations of the HIV epidemic in the country need to adopt a similar approach to inform the design of appropriate state-level strategies for HIV prevention in urban and rural areas.

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