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District-level HIV estimates using the spectrum model in five states of India, 2017

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Abstract

Decentralized response has been the hallmark of the National AIDS Control Programme in India. District-level HIV burden estimates quantifying the distribution of the epidemics are needed to enhance this decentralized response further to monitor the progress on prevention, testing, and treatment interventions. In this paper, we describe the methodology and results of district-level estimates using the Spectrum model piloted in 5 states of India under National AIDS Control Programme.

Using state spectrum model for HIV estimations 2017, we disaggregated state results by the district in pilot states. Each district was considered a subepidemic and HIV epidemic configuration was carried out in its general population as well as in key population. We used HIV surveillance data from antenatal clinics and routine pregnant women testing to model the general population's epidemic curve. We used HIV prevalence data available from HIV sentinel surveillance and integrated biological and behavioral surveys to inform the epidemic curve for key population. Estimation and projection packgage classic platform was used for the curve fitting. District-wide estimates extracted from subpopulation summary in Spectrum results section were used to calculate relative burden for each district and applied to approved State HIV Estimations 2017 estimates.

No district in Tamil Nadu had an adult HIV prevalence of higher than 0.5% except for one, and the epidemic seems to be declining. In Maharashtra, the epidemic has shown a decline, with all except 5 districts showing an adult prevalence of less than 0.50%. In Gujarat and Uttar Pradesh, few districts showed rising HIV prevalence. However, none had an adult prevalence of higher than 0.50%. In Mizoram, 6 of 8 districts showed a rising HIV trend with an adult prevalence of 1% or more in 5 districts.

Disaggregation of state-level estimates by districts provided insights on epidemic diversity within the analyzed states. It also provided baseline evidence to measure the progress toward the goal of end of AIDS by 2030.

Abbreviations: ART = antiretroviral therapy, EPP = estimation and projection packgage, FSW = female sex workers, H/TG = hijra/transgender people, HSS = HIV sentinel surveillance, KP = key population, MSM = men who have sex with men, NACP = National AIDS Control Programme, PLHIV = people living with HIV, PMTCT = prevent mother-to-child transmission, PWID = people who inject drugs, UNAIDS = the Joint United Nations Programme on HIV/AIDS.

Keywords: district, epidemiologic methods, estimates, estimations, HIV, incidence, India, models, prevalence, subepidemic

1. Introduction

1.1. Background and objectives

India has the highest burden of HIV in the Asian region and the second largest in the world, with an estimated 2.35 million people living with HIV (PLHIV).[1,2] The epidemic is highly variable both between and within the states as is between different subpopulations. Adult HIV prevalence in 2019 has been estimated to range from as high as 2.32% in the North-Eastern state of Mizoram to 0.06% in Union Territory of Jammu & Kashmir and Ladakh. Similarly, prevalence among people who inject drugs (PWID), men who have sex with men (MSM), hijra/transgender (H/TG) people, prisoners, and female sex workers (FSW) was variable and 7 to 28 times higher than adult HIV prevalence.[3,4]

Given the magnitude and trajectory of the HIV epidemic at present, India is committed to achieving Sustainable Development Goals target 3.3 of "End of AIDS" as reflected in the 7-year national strategic plan.[5] This commitment necessitates enhanced focus on understanding the HIV epidemic at a more granular level for priority action.[6]

Evidence-driven prioritization for resource allocation started with categorizing states at the start of National AIDS Control Programme (NACP)-2 using HIV Sentinel Surveillance data.[7,8] Again, at the beginning of NACP-3 (2008–2009), 195 districts were identified as high-priority districts.[9] As the focus shifted to "End of AIDS," monitoring the epidemiological parameters at district level became a critical[10,11] both to facilitate resource allocation and to track the progress at granular level.[6,12] An expert consultation was convened to discuss newer methods to achieve district-level HIV estimation.[13] This paper presents the recommended method details and the results obtained by their implementation in 5 districts on the pilot basis.

2. Methods

2.1. Spectrum model

Under NACP, Statewide HIV estimation in India is undertaken biennially using the Joint United Nations Programme on HIV/AIDS (UNAIDS) supported Spectrum Software. The details of the process and method for the same had been described elsewhere.[14–16] In brief, the model takes state-specific demographics, HIV treatment coverage (number on antiretroviral therapy [ART], the number receiving prophylaxis/treatment to prevent mother-to-child transmission [PMTCT]) and epidemiological data (HIV sentinel surveillance [HSS], national family health surveys, integrated biological and behavioural surveillance) as critical inputs and uses these to produce outputs on HIV prevalence, incidence, mortality, and PMTCT needs. The curve fitting process estimates the incidence from the prevalence trend. The incidence thus generated is used by the model to quantify the consequences of the epidemic using assumptions on age and gender disaggregation of new infections and mortality among HIV-infected people with and without ART. The model and assumptions are updated periodically as new evidence emerges under the recommendation of the UNAIDS reference group on estimates, modeling, and projections.[17] The details of the update are made available on the developer website (https://avenirhealth.org/software-spectrum.php).

2.2. Approach for district-level HIV burden estimates

We used the State model prepared for 2017 round through Spectrum 5.63 of HIV Estimations in India under NACP as starting point for disaggregating district-level HIV burden. The spectrum-based model under HIV Estimations 2017 was available for 35 states/union territory under NACP. The states of Gujarat, Maharashtra, Mizoram, Tamil Nadu, and Uttar Pradesh were selected for the pilot exercise. Table in supplementry material provides key indicators on HIV epidemic for the pilot states.

Data inputs on demographics, HIV treatment coverage, mortality, fertility, and age/sex pattern of HIV incidence were already available in selected states' base models. For district-level HIV burden estimation, we first created each district as a subepidemic under epidemic configuration in the base state model. Then specific subpopulation groups (general population, FSW, MSM PWID, and H/TG) were created under each subepidemic (district). Population aged 15 to 49 years, per cent male population, and turnover were entered for each subpopulation in each subepidemic.

In the next step, we inputted HIV prevalence data for each subpopulation for each subepidemic. Epidemic curve based on prevalence data was fitted for each subpopulation in each subepidemic using Estimation and Projection Packgage (EPP) in Spectrum. EPP provided incidence curves for all subpopulations. Spectrum used these incidence curves and other inputs like treatment coverage and fertility and mortality assumptions to generate age-specific and gender-specific incidence, prevalence, and mortality estimates. The subepidemic (district) wide results were then generated through Spectrum, which provided district-wide estimates.

The district-level estimates thus generated using Spectrum subepidemic (district) model were used to calculate the district-wide relative burden of HIV population, new HIV infection, annual AIDS death, and PMTCT need over the years among the 15+ years population. The district-wide relative burden thus derived was applied to 2017 State estimates from the base model of Spectrum to obtain the disaggregated State 2017 estimates by their constituent districts. The process ensured that the total of all district-level HIV estimates for key indicators added up to the aggregated 2017 HIV estimates. The uncertainty bound pattern for state estimates was applied to various district-level estimates. Figure in supplementry material summarizes the key steps for district-level HIV burden estimations.

2.3. Data inputs

2.3.1. Subpopulation characteristics.
One or more subpopulation groups were created under each subepidemic (i.e., district) based on the availability of data on the size of a given subpopulation. The subpopulation groups included FSW, MSM, PWID, and H/TG categories to represent key population (KP) and the general population group (remaining population). Data on the size, per cent male population, and turnover for each subpopulation were inputted.

Population projections for different years were available only up to state level. To derive the adult (15–49 year) population of a district for the years under projection, we first computed its percentage contribution to state adult population in 2011 (Census year). We applied this proportion to the projected state population in subsequent years.

Share of male/female and average time spent in group, and data source on subpopulation.

Subpopulation	% male	Average time spent in group	HIV prevalence data source (years of data collection)*
FSW	0.00	8.00	HSS from 1998 to 2007, 2009, 2011, 2017
MSM	100.00	NA	HSS from 2000 to 2007, 2009, 2011, 2017
PWID	90.00	15.00	HSS from 1999 to 2007, 2009, 2011, 2017
H/TG	100.00	NA	HSS from 2006 to 2007, 2009, 2011, 2017
GP	50	NA	HSS from 1998 to 2007, 2008, 2010, 2013, 2015, and 2017; Routine testing data from 2010 to 2017

* District-wise variation in the availability of HSS data as HSS sites were scaled up in phases.

For a category of KP (FSW, MSM, PWID, or H/TG), a subpopulation was created within a subepidemic (district) if mapping and population size estimates were available. Mapping and population size estimates data were computed as a proportion of adult (15–49 year) population for the year of population size estimation and this proportion was applied across the projection years to estimate the size of the KP group concerned. Then aggregated size of the KP was subtracted from the total adult population to estimate the size of the remaining (general) population.

Estimates of the proportion of the male population in each subpopulation were informed based on the advice received from national experts, including those from UNAIDS. Same was also done for the turnover, that is, length of time for which an individual remains in a subpopulation group before moving out. Table 1 summarizes subpopulation characteristics used in the estimation process.

2.3.2. HIV prevalence. HIV prevalence data for each subpopulation group came from HSS being undertaken under NACP since 1998. For the subpopulation groups of FSW, MSM, PWID, and H/TG, prevalence data from HSS were inputted. For the general population subpopulation-group, prevalence data from HSS among antenatal clinic attendees as well as routine HIV testing data from pregnant women was inputted (Table 1).

For each subpopulation in each of the subepidemic/district, the prevalence data points were either inputted wherever available from sites in the districts or were borrowed and inputted from neighboring districts. Data were not borrowed from the neighboring districts if the subpopulation had at least 1 surveillance site with data available for minimum 3 different time points or more than 1 surveillance site with data over minimum 2 distinct periods.

HIV estimations is a periodic activity under the NACP of the Government of India. No primary data collection was done for the district-level HIV burden estimations (2017) and the activity relied on the analysis of already available aggregated deidentified demographic, programmatic, and surveillance data to inform the model parameters. As there was no primary data collection for district-level HIV burden estimations (2017), the ethics review was not sought.

3. Results

Table 2 summarizes the district-level estimates in the 5 selected states of India for the year 2017. Figures 1 to 3 present district-wide HIV prevalence level, trend and PLHIV size estimates for Gujarat, Maharashtra, Mizoram, Tamil Nadu, and Uttar Pradesh, respectively. Detailed district-wide results are presented in tables in Supplement 1.

In Gujarat, in 2017, around 92,000 people were estimated to be living with HIV (PLHIV). District-wide, Surat and Ahmedabad, each had more than 10,000 HIV infected people. Kheda, Sabarkantha, and Bhavnagar each had PLHIV in the range of 5000 to 10,000. The districts of The Dang, Gandhinagar, and Narmada are estimated to have less than 1000 PLHIV. The rest of Gujarat's districts were estimated to have PLHIV in the range of 1000 to 5000. Overall adult (15+ years) HIV prevalence in Gujarat was 0.19%; with the highest prevalence in Kheda (0.46%) followed by Sabarkantha (0.34%), Surat (0.29%), Surendra Nagar (0.27%), Dahod (0.25%), Bhavnagar (0.24%), Mehsana (0.21%), and Navsari (0.20%). After declining, the prevalence trend has been stabilizing in most districts in recent years. However, the HIV trend rose in a few Gujarat districts, including Kheda, Mehsana, Narmada, Panchmahal, and Dang. Of the 4365 estimated annual new HIV infections among adults (15+ years) in Gujarat in 2017, Kheda had the maximum (19%) new HIV infections followed by Surat (13%), Ahmedabad (10%), Mehsana (7%), and Bhavnagar (6%). The estimated PMTCT need for state in 2017 was around 1300 with districts of Surat, Ahmedabad, and Kheda with an estimated PMTCT need ranging between 100 and 225.

In Maharasthra, in 2017, there were estimated around 330,000 PLHIV. Districts of Mumbai suburban and Mumbai had around 44,000 PLHIV (13% of total PLHIV in state). Districts of Pune, Thane (including Palghar), and Solapur, each had 20,000 to 30,000 PLHIV. Sangli, Nagpur, Nashik, Mumbai City, Nanded, and Kolhapur were other districts in state with more than 10,000 PLHIV. While overall adult HIV prevalence (15+ years) in Maharashtra state was 0.36%, the district of Sangli had an adult HIV prevalence more than twice of the state average. Solapur, Akola, Dhule, and Buldhana were the other districts with an adult HIV prevalence of 0.50% or more. The prevalence trend has been declining across every district. The state had around 5700 new HIV infections in 2017 among adults. District-wide, Solapur is estimated to have the highest annual new HIV infections in state (around 1100). Akola, Mumbai Suburban, Buldana, Dhule, and Nanded were the other districts with annual 500 new HIV infections. The estimated PMTCT need for the state in 2017 was around 2400; with Mumbai (City and Suburban) districts having almost 325 HIV-positive women in need of PMTCT services. Districts of Thane (including Palghar) and Pune were the other districts with an estimated need for PMTCT services closer to 200 each.

In Mizoram, the estimated number of PLHIV in 2017 was 16,800, with around 10,400 in the district of Aizawl alone.

Table 2

State/district-wide summary estimates of adult HIV prevalence, PLHIV, annual new infections, AIDS-related deaths, and PMTCT need (2017).

| Indicator	Gujarat	Maharashtra	Mizoram	Tamil Nadu	Uttar Pradesh
Districts (number)	26	35	8	32	71
HIV prevalence (%) (15+ yr)	0.19	0.36	2.06	0.25	0.09
Number of districts by HIV prevalence category					
<0.25%	21	9	0	22	70
>=0.25%–<0.50%	5	21	1	9	1
>=0.50%–<0.75%	0	4	2	1	0
>=0.75%–<1.00%	0	1	0	0	0
>=1%	0	0	5	0	0
PLHIV (number)	91,800	329,700	16,800	141,900	134,000
Number of districts by PLHIV (number) category					
<1000	3	0	4	2	25
>=1000–<5000	18	14	3	17	44
>=5000–<10,000	2	8	0	12	2
>=10,000–<15,000	1	8	1	0	0
>=15,000–<20,000	1	1	0	1	0
>=20,000–<25,000	1	1	0	0	0
>=25,000	0	3	0	0	0
Annual new HIV infections (number) (15+ yr)	4350	5700	1450	3500	6600
Number of districts by new HIV infections (number) category					
<100	9	19	5	20	38
>=100–<500	15	11	2	11	32
>=500–<1000	2	4	1	1	1
>=1000	0	1	0	0	0
Annual AIDS-related deaths (number) (15+ yr)	2050	9900	450	2750	3550
Number of districts by AIDS-related deaths (number) category					
<100	16	5	7	18	49
>=100–<500	10	25	1	14	22
>=500	0	4	0	0	0
>=1000–<1500	0	1	0	0	0
Annual PMTCT need (number)	1300	2400	250	1150	2300
<50	8	7	7	14	35
>=50–<100	14	18	1	17	31
>=100–<150	4	6	0	0	5
>=150–<200	0	3	0	1	0
>=200	0	1	0	0	0

Detailed district-wide results are presented in the supplementary materials.

Champai district had an estimated PLHIV size of around 2100 followed by Lunglei (around 1300) and Mamit (around 1100). Remaining districts in state had 1000 or less PLHIV. While overall adult prevalence was 2.06% in Mizoram; Aizawal had the high prevalence (3.29%) followed by 2.31% in Champai which were above the state average. Mamit, Kolasib, and Lunglei were the other districts with adult prevalence of more than 1% in the state. The HIV prevalence trend was observed to be rising in districts of Aizawl, Mamit, Kolasib, Champaii, Serchiip, and Saiha but has stabilized in Lunglei and Lawngtlai. Overall, there were around 1500 new HIV infections among adults in the state; approximately 900 of them were estimated to be in Aizawl. The estimated PMTCT need for state in 2017 was around 260 with the district of Aizawl requiring nearly 60% of the total need.

In Tamil Nadu, in 2017, there were around 141,900 PLHIV. The highest number of PLHIV were estimated to be in Salem (16,300) followed by 9000 in Vellore. The districts of Madurai, Coimbatore, Erode, Tirunelveli, Kanchipuram, Namakkalm, Tiruvallur, Dharmapuri, and Tiruchirappalli had estimated 5000 to 9000 PLHIV. Each of Tiruppur, Cuddalore, Krishnagiri, Ramanathapuram, Virudhunagar, Tiruvannamalai, Pudukkottai, Dindigul, Kanyakumari, Tiruvarur, and Nagapattinam had

an estimated 2000 to 5000 number of PLHIV. Remaining districts had an estimated 1000 to 2000 PLHIV except for Perambalur and The Nilgiris which had less than 1000 PLHIV. HIV prevalence among adults (15+years) in Tamil Nadu state was estimated at 0.25% in 2017. Salem had the highest estimated adult HIV prevalence at 0.59%, followed by Dharmapuri (0.42%), Namakkal (0.39%), Erode (0.38%), and Madurai (0.32%). The HIV prevalence showed a declining trend across the districts. Overall, nearly 3500 new HIV infections among adults were estimated in the state in 2017 with Salem having the highest (around 550). Viluppuram, Chennai, Madurai, Coimbatore, Kanchipuram, Vellore, and Erode were other districts with 200 or more new HIV infections among adults in 2017. In the rest of Tamil Nadu's districts, less than 200 annual new HIV infections were estimated in 2017. The estimated PMTCT need for the Tamil Nadu state in 2017 was around 1200. District-wide, the PMTCT need was less than 100 in each of the districts except in Salem.

Uttar Pradesh was estimated to have around 132,600 PLHIV in 2017 with 2 districts of Gorakhpur and Lucknow having 5200 and 5400 PLHIV respectively. Kanpur Nagar, Basti, Aligarh, Ballia, Jaunpur, Sultanpur, Deoria, Ambedkar Nagar, Rae Bareli,
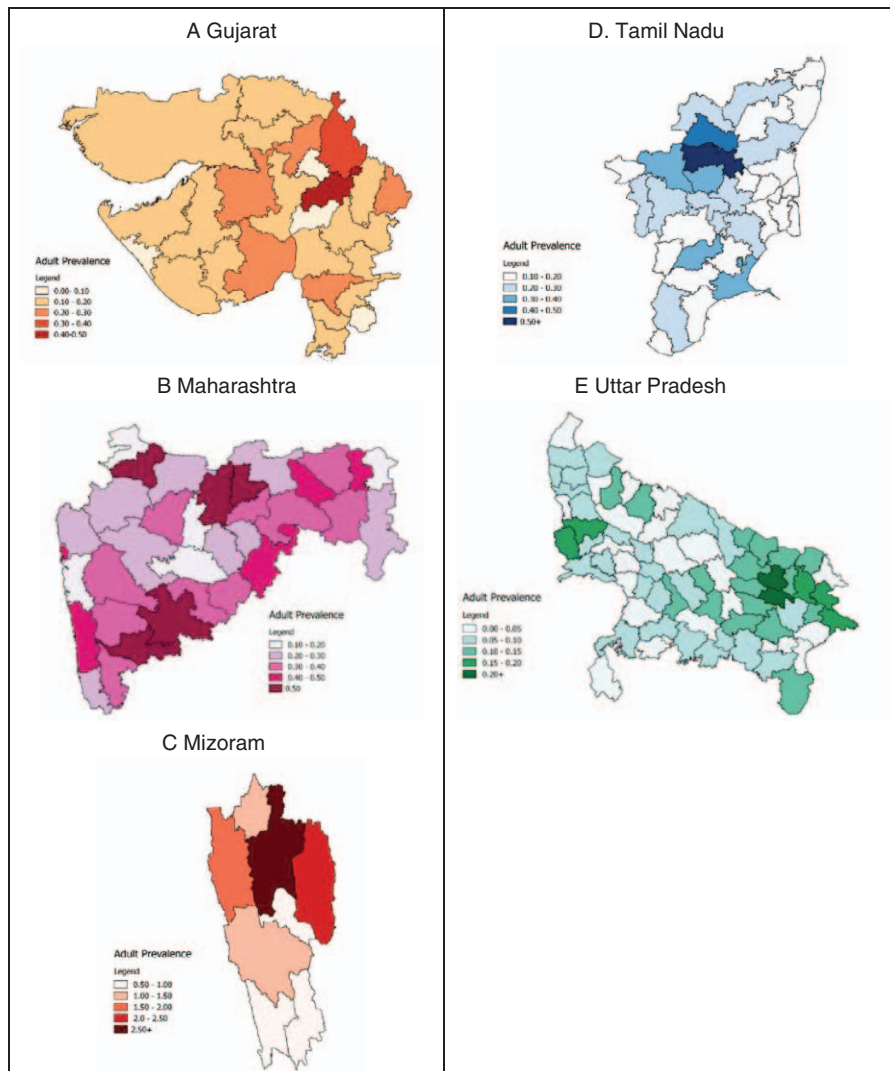
Figure 1. Adult (15+ yr) HIV prevalence (%) in 2017. A, Adult HIV prevalence by districts in Gujarat. Color bins correspond to the 0.00 to 0.10, 0.10 to 0.20, 0.20 to 0.30, 0.30 to 0.40, and 0.40 to 0.50 to highlight variation within state of Gujarat. B, Adult HIV prevalence by districts in Maharashtra. Color bins correspond to the 0.10 to 0.20, 0.20 to 0.30, 0.30 to 0.40, 0.40 to 0.50, and >0.50 to highlight variation within state of Maharashtra. C, Adult HIV prevalence by districts in Mizoram. Color bins correspond to the 0.50 to 1.00, 1.00 to 1.50, 1.50 to 2.00, 2.00 to 2.50, and >2.50 to highlight variation within state of Mizoram. D, Adult HIV prevalence by districts in Tamil Nadu. Color bins correspond to the 0.10 to 0.20, 0.20 to 0.30, 0.30 to 0.40, 0.40 to 0.50, and >0.50 to highlight variation within state of Tamil Nadu. E, Adult HIV prevalence by districts in Uttar Pradesh. Color bins correspond to the 0.00 to 0.05, 0.05 to 0.10, 0.10 to 0.15, 0.15 to 0.20, and >0.20 to highlight variation within state of Uttar Pradesh.

Moradabad, Gonda, Bareily, Allahabad, Ghaziabad, Pratapgarh, Muzaffarnagar, Kheri, Mathura, Mahrajganj, Bahraich, Bijnor, Siddharthnagar, Unnao, Faizabad, Azamgarh, Mau, and Balrampur had an estimated PLHIV size between 2000 and 4500. Rest of the districts had less than 2000 PLHIV including districts of Auraiya, Baghpat, Barabanki, Budaun, Chandauli, Chitrakoot, Etah, Etawah, Fatehpur, Hamirpur, Jalaun, Lalitpur, Mahoba, Mainpuri, Pilibhit, Rampur, Saharanpur, Shajahanpur, Sitapur, and Varanasi. While overall adult HIV prevalence among persons 15 years or more was estimated at 0.10% in the state of Uttar Pradesh, districts of Basti, Ambedkar Nagar, Ballia, Deoria, Aligarh, Gorakhpur, Mathura, Gonda, Rae Bareli, Sultanpur, Balrampur, Shrawasti, Lucknow, and Siddharthnagar had an estimated prevalence of almost 1.5 to 3 times more than that of the state average. Adult HIV prevalence in Meerut, Pilibhit, Fatehpur, Mahamaya Nagar, Mainpuri, Jalaun, Mahoba, Bijnor, Etah, Rampur, and Auraiya has shown a rising trend; but it has been either declining or remained stable in most of the other districts. Around 6600 new HIV infections among adults (15+ years) were estimated in Uttar Pradesh in 2017. The district of Aligarh had around 500 new HIV infections. Ambedkar Nagar (424), Lucknow (285), Kanpur Nagar (253), Sultanpur (224), Rae Bareli (220), Gonda (208), Bijnor (206), Gorakhpur (205), Deoria (203), Moradabad (202) were the other districts with an estimated 200 to 450 new HIV infections among adults in 2017. The estimated PMTCT need for the state of Uttar Pradesh in 2017 was around 900. District-wide, the PMTCT need was less than 100 in each of the districts.
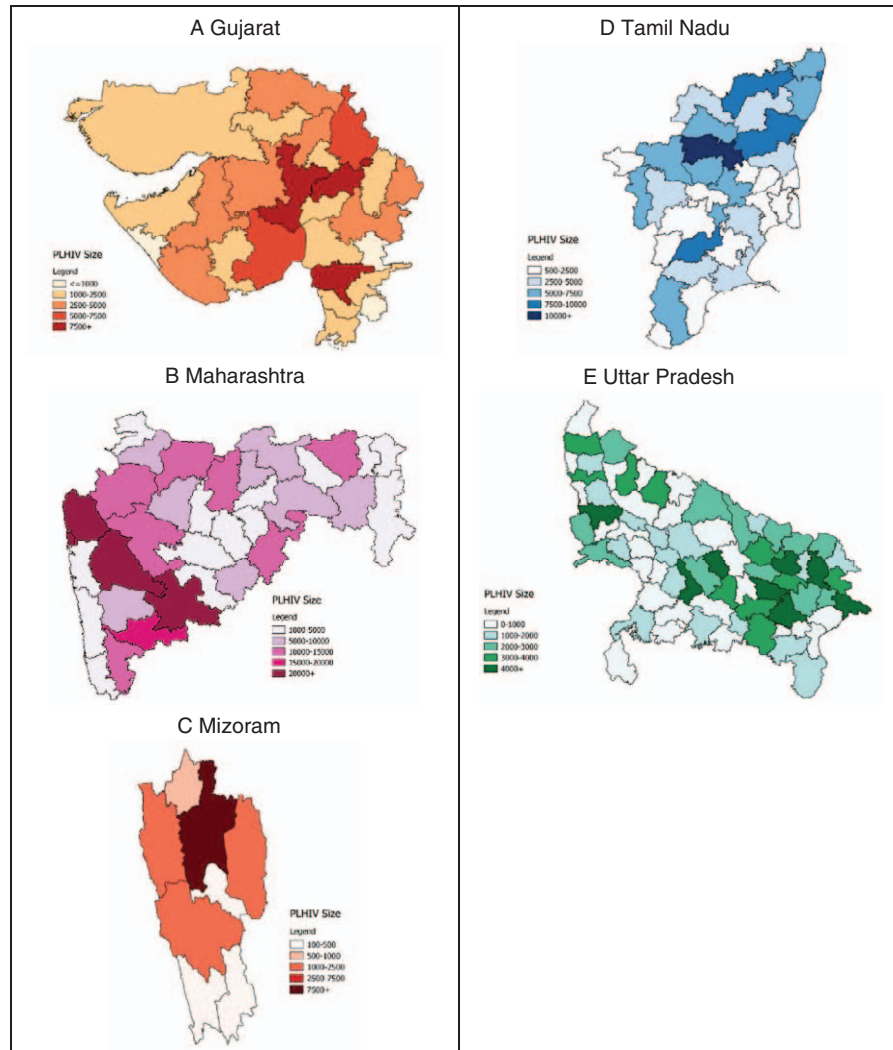
Figure 2. PLHIV estimates in 2017. A, District-wide number of PLHIV in Gujarat. Color bins correspond to the <1000, 1000 to 2500, 2500 to 5000, 5000 to 7500, and >7500 to highlight variation within state of Gujarat. B, District-wide number of PLHIV in Maharashtra. Color bins correspond to the <5000, 5000 to 10,000, 10,000 to 15,000, 15,000 to 20,000, and > 20,000 to highlight variation within state of Maharashtra. C, District-wide number of PLHIV in Mizoram. Color bins correspond to the <500, 500 to 1000, 1000 to 2500, 2500 to 7500, and more than 7500 to highlight variation within state of Mizoram. D, District-wide number of PLHIV in Tamil Nadu. Color bins correspond to the <2500, 2500 to 5000, 5000 to 7500, 7500 to 10,000 and > 10,000 to highlight variation within state of Tamil Nadu. E, District-wide number of PLHIV in Uttar Pradesh. Color bins correspond to the <1000, 1000 to 2000, 2000 to 3000, 3000 to 4000, and >4000 to highlight variation within state of Uttar Pradesh.

4. Discussions

Quantifying the HIV burden and trends of key indicators at the districts level is needed to understand the diversity of the HIV epidemic and also for planning, implementation, progress monitoring, and impact assessment of NACP. This is likely to inform the national program about the locations that need to be prioritized and package of services that need to be rolled in the priority districts. This paper describes a Spectrum-based method for district-level HIV burden estimations from 5 epidemiologically and programmatically divergent states of India. Spectrum model has been used in India and across the world for HIV burden estimations at the national and subnational levels. We have generated district-level HIV burden estimates through the disaggregation of state model. We recommend that the proposed method can be adopted by other countries that also have a concentrated HIV epidemic.

District-level HIV burden estimates provided critical insights into the diversity of the HIV epidemic in each state. On one end of the spectrum are the states of Maharashtra and Tamil Nadu, where the epidemic is declining across the state and prevalence is less than 0.50% in most of the districts. Then, there are states of Gujarat and Uttar Pradesh, where prevalence is less than 0.50% in all districts, but trends are diverse with some showing a rising trend. Mizoram is on the other end of spectrum where rising prevalence in most districts with 5 of total 8 districts had an adult prevalence of 1.00% or more.

Additionally, specific district-wide information on indicators such as estimates of PLHIV and annual new HIV infections can provide important inputs to the programme managers to
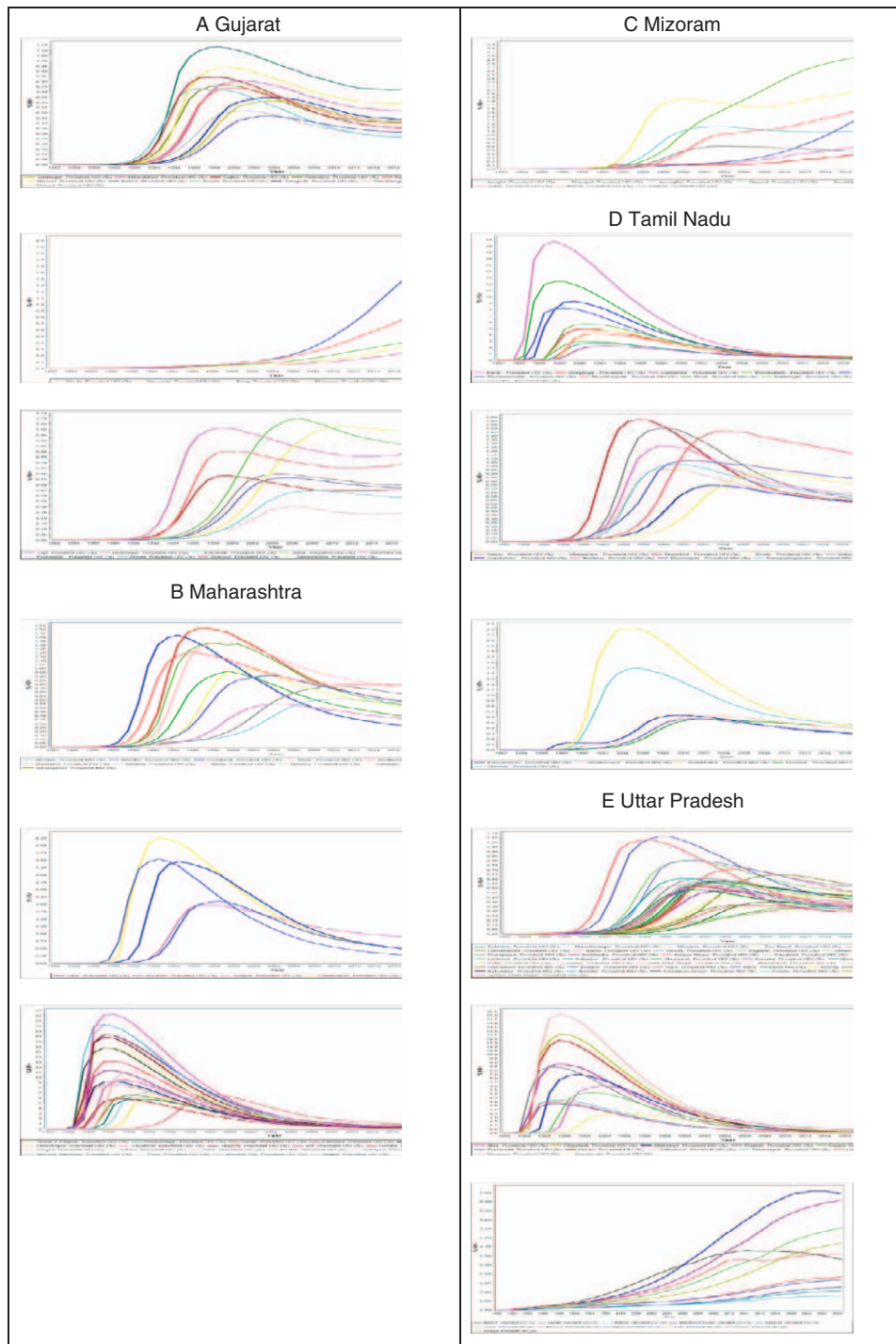
Figure 3. Adult HIV prevalence (%) trend in 2017. This trend is from the EPP module of Spectrum. A, Adult HIV prevalence trend by districts in Gujarat. Districts in the state are grouped in 3 figures (i, ii, and iii) showing the trend. B, Adult HIV prevalence trend by districts in Maharashtra. Districts in the state are grouped into 3 figures (i, ii, and iii) showing the trend. C, Adult HIV prevalence trend by districts in Mizoram showing the adult prevalence trend. D, Adult HIV prevalence trend by districts in Tamil Nadu. Districts in the state are grouped in 3 figures (i, ii, and iii) showing the trend. E, Adult HIV prevalence trend by districts in Uttar Pradesh. Districts in the state are grouped into 3 figures (i, ii, and iii) showing the trend.

customize the response appropriately. Special attention will be required to be given on districts of Mizoram state, many of which showed higher and rising adult prevalence, and many districts from Uttar Pradesh that have a large population. With an adult

prevalence of 3.00%, Aizwal district in Mizoram was home for around 10,400 PLHIV in 2017. In contrast, Gorakhpur and Lucknow districts in Uttar Pradesh had an estimated adult HIV prevalence which is one-twentieth of Aizwal (~0.15%), but put

together, more PLHIV than that in Aizwal district. Similarly, in Salem in Tamil Nadu, with an adult prevalence of 0.60%, had almost 60% higher PLHIV than in Aizwal because of the large population size. Our analysis helped identify districts that may be prioritized for HIV response and the type of services that need to be focused on each of them.

From a methodological perspective, our analysis using Spectrum to generate district-level HIV burden exercise was the first of its kind. Earlier, Spectrum had been used in India and also in many other countries to make epidemiological estimates at subnational levels.[1,2,12,18]

Going further down from states to districts helped us achieve more granularity and establish the in-country capacity to carry forward this initiative even in the future and expand it to the other states of India. We learnt that the structure and well-defined step-wide approach of the Spectrum model might help standardize and implement this approach to a large country like India with 700 plus districts.[19] The information on trends of the key indicators at the district level over the years will prove critical in understanding and exploring the reasons for the diversity of the HIV epidemic at micro-level in India.

There are certain limitations in this approach which are inherent to any estimations exercises but still need to be taken into account while interpreting the results.[12,20–22] Spectrum does not directly account for some of the other important considerations like the prevalence of sexually transmitted infections, type of ART treatment regimen, number of treatment failures, viral suppression rates, HIV testing rates, etc, and our approach of district-level burden estimations using Spectrum has some limitations due to inherent ability of the model in the present form. However, the Spectrum model is continuously evolving, and these features may be added in the years to come.

The approach assumes that the demographics parameters such as crude birth rates, age-specific fertility rates, and the age-sex pattern in various districts are uniform and are the same as those of state. This assumption is primarily driven by the lack of availability of the critical demographics inputs at the districts level. Therefore, it will be essential to strengthen the public health data and surveillance systems tracking such data at the district level in the future.

In the Spectrum model, as there is no provision for using ART and PMTCT data by subepidemics, the EPP distributes these data entered at the state level in districts based on the number of PLHIV in each district. As there would always be gaps between the estimated number of PLHIV and those covered under ART services or those requiring PMTCT services, the numbers requiring and utilizing services might be modeled inaccurately. Application of validated PLHIV on ART data at the district level by residence under the "SOCH" application being developed under NACP will further improve estimation in due course.[23]

Data for HIV prevalence and the size of the KP population at the districts level are sparse, especially in low prevalence states like Uttar Pradesh. Although the use of data from the neighboring districts is the current workable solution, lack of size estimation of KP in many districts might underestimate the HIV epidemic size in such districts. The NACP in India is undertaking a country-wide mapping, and population size estimation of KP population.[24] These data can be inputted in Spectrum as and when they become available to further improve the district level estimation's robustness.

At state level, HIV Estimations in India have traditionally used results from representatives HIV prevalence from other commu-nity-based surveys such as National Family Health Survey and Integrated Biological and Behavioural Surveillance Survey as a gold standard to inform the level of HIV epidemic. Currently, there are no gold standards against which we can compare the quantified district-level HIV epidemiological estimates. To determine the representatives of the estimated HIV prevalence in the absence of reliable and representative community-based surveys at the district level, data triangulation methods using local intelligence will have to be developed.

The efforts required to carefully review the inputs data and fit the epidemic curve become more and more challenging in case of multiple subepidemics with multiple subpopulations. In this context, district-level estimation helped in training and building the program staff at the State AIDS Control Societies under the National AIDS Control Programme.

We strongly believe that district-level HIV burden estimation is an essential step in enhancing the country-wide evidence that would improve the efficiency of district-based planning, implementation, monitoring, and impact assessment of the NACP. The estimates being made available will be critical enablers for strategizing and financing the prioritized district locations. It will be essential to measure the progress on UNAIDS 95–95-95 targets in all such districts.

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